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ORIGINAL PAPERS

A CHROMIUM RED GLAZE[1]

BY CHARLES F. BINNS AND ELEANOR CRAIG

ABSTRACT

An attempt to make use of the red color of basic lead chromate in a glaze maturing about cone 08.

The basic chromate of lead has long been known as a coloring agent but its use, so far as published information goes, has been limited to the overglaze color known as coral red. For this color numerous recipes are in existence but the brilliant scarlet which results from any of these is destroyed even by an accidental rise in temperature in the decorating kiln. The aim of the present study was to ascertain whether a brilliant red, or any red, could be obtained from the basic chromate under the conditions of glazing and glaze fire.

A beginning was made with the formula:

$$\left.\begin{matrix} PbO & .9 \\ CaO & .1 \end{matrix}\right\} \left\{\begin{matrix} Al_2O_3 & .2 \\ Cr_2O_3 & .1 \end{matrix}\right\} SiO_2 \quad .7$$

Batch

Lead chromate	37	Flint	18
White lead	206	Georgia clay	51.6
Whiting	10		

The whole was fritted and fired to cones 09, 08, and 04 respectively. The lower temperatures resulted in a red and an orange but the cone 04 fire produced a green glaze.

[1] Received December, 1926. For presentation at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., Feb. 1927. (Art Division.)

Changes were then made in the formula and ultimately the following was arrived at:

$$\left.\begin{matrix} PbO & .9 \\ CaO & .1 \end{matrix}\right\} \left.\begin{matrix} Al_2O_3 & .2 \\ Cr_2O_3 & .2 \end{matrix}\right\} SiO_2 \quad .7$$

This when fired at cone 08 was not fused, but at cone 04 was a deep red with green under the red and bordering it.

At this point borax was added, arriving at the formula:

$$A \quad \left.\begin{matrix} PbO & .8 \\ CaO & .1 \\ Na_2O & .1 \end{matrix}\right\} \left.\begin{matrix} Al_2O_3 & .2 \\ Cr_2O_3 & .25 \\ B_2O_3 & .2 \end{matrix}\right\} SiO_2 \quad .7$$

Batch

Whiting	10.0	Borax	38.2
Lead chromate	80.5	Clay	51.6
Red lead	126.4	Flint	30.0
			358.5

When fritted, and fired at cone 08 this showed a slight green tint within a dark red.

A published recipe called nasturtium red was then tried in which potassium bichromate was used. This at cone 08 proved too fluid so that several changes were indicated as follows:

$$\begin{matrix} N\ I & \left.\begin{matrix} PbO & .88 \\ K_2O & .06 \\ Na_2O & .06 \end{matrix}\right\} & \left.\begin{matrix} Cr_2O_3 & .06 \end{matrix}\right\} & SiO_2 & 1.0 \\ N\ II & \left.\begin{matrix} PbO & .76 \\ K_2O & .10 \\ Na_2O & .14 \end{matrix}\right\} & \left.\begin{matrix} Cr_2O_3 & .10 \\ B_2O_3 & .28 \end{matrix}\right\} & SiO_2 & 1.4 \\ N\ III & \left.\begin{matrix} PbO & .70 \\ K_2O & .12 \\ Na_2O & .18 \end{matrix}\right\} & \left.\begin{matrix} Cr_2O_3 & .08 \\ Al_2O_3 & .06 \\ B_2O_3 & .36 \end{matrix}\right\} & SiO_2 & 1.8 \end{matrix}$$

These were all fritted.

N I. At cone 08 was a red transparent glaze which crazed in cooling.

N II. Fired an orange crystalline at cone 08.

N III. Fired yellow-green with patches and streaks of red evenly distributed at cone 08.

Making a triangle of A, N, I and N, II, it was found that a combination of A and N I would give the desired red at cone 08.

The formula of this is:

$$\left.\begin{matrix} PbO & .88 \\ K_2O & .049 \\ Na_2O & .06 \end{matrix}\right\} \left.\begin{matrix} Cr_2O_3 & .049 \\ Al_2O_3 & .1 \end{matrix}\right\} SiO_2 \quad 1.3$$

Batch

Red lead	200.60	Soda ash	6.12
Bichromate of potash	14.40	Georgia clay	25.80
		Flint	54.00
			300.92

The whole glaze is fritted and ground.

N. Y. School of Clayworking and Ceramics
Alfred, N. Y.

COLORED BODIES[1]

By Charles F. Binns and Hallie Elayne Wardner

Abstract

Experiments were conducted to find a palette of colored bodies which could be worked, and their proper glazes. The formulas obtained are given.

The object of the following experiments was to find a palette of colored bodies which could be worked together successfully, and to find the proper glaze for them. The colors, blue, green, red, brown, and yellow were chosen. Tests were made in order to secure clays of like shrinkage and porosity, which was necessary for the successful working of them together. The following are the most successful mixtures:

Green

Johnson Porter ball clay	5	Flint	10
English ball clay	52	Cryolite	5
Feldspar	15	Chrome oxide	3

Brown

Monmouth clay	24	Flint	4
Campbell's red clay	24	Burnt umber	1.04

Red

Monmouth clay	18	Flint	3
Campbell's red clay	18		

Yellow

Zanesville yellow Clay

Blue

English china clay	106	Cryolite	10
Feldspar	30	Cobalt oxide	.8
Flint	20		

Several tests were made for a yellow clay, using Zanesville yellow and Monmouth clay in different proportions, but none was satisfactory. They did not mix well together and the color was not good, so a test was made of the Zanesville yellow clay alone and this proved very good.

A small cup-shaped test was made, welding the clays, a different body for each coil, together in the following order:

Red	6	Yellow	4	Brown	2
Blue	5	Green	3	Monmouth	1

This test was fired to a point half-way between cone 05 and cone 04. After firing the porosity and shrinkage of each clay appeared equal, and the colors were very satisfactory.

The following glaze, maturing at cone 04, was found to work well:

$$\left.\begin{matrix} PbO & .55 \\ CaO & .35 \\ K_2O & .10 \end{matrix}\right\} \quad Al_2O_3 \quad .20 \quad \left.\right\} \quad SiO_2 \quad 1.60$$

[1] Received December, 1926. For presentation at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb. 1927. (Art Division.)

White lead	141.9	Georgia clay	12.9
Whiting	35.	Flint	31.8
Eureka feldspar	82.9		

A pitcher was then designed and built which included in the building the red, yellow, and brown bodies. A pattern was painted upon the pitcher using the blue and green bodies in slip form. The pitcher fired as satisfactorily as did the test and was glazed with the colorless transparent glaze.

New York School of Clayworking and Ceramics
Alfred, N. Y.

A PRELIMINARY STUDY OF THE RESISTANCE TO ABRASION OF CERAMIC GLAZES, ITS CONTROL AND METHODS OF DETERMINATION[1]

By A. C. Harrison

ABSTRACT

Two test methods, one using an Ingersoll glarimeter to obtain results of a high degree of accuracy, and the other simpler "alternate method" for plant control, are described in detail. Tests on commercial hotel chinaware showed the average resistance of foreign ware was higher than that of the domestic and the variation from the average was, in general, less. Experimental glazes were prepared to study the effect on resistance, of: (1) varying SiO_2 and Al_2O_3 content, (2) glaze thickness, and (3) firing treatment. Data obtained are insufficient to justify definite conclusions regarding the effect of varying SiO_2 and Al_2O_3, but do show the resistance of well-matured glazes to be inversely proportional to thickness, a decrease in resistance as the tendency to matt increases, a markedly increased resistance by the higher glost fire. That type of body affects resistance less than do glaze composition and temperature of glost fire.

Introduction

This work is a continuation of that begun by W. J. Scott[2] in 1923. The essential features of the investigation include: (1) the development of a satisfactory abrading device and means of measuring abrasion; (2) the comparison of the glazes of ten brands of hotel chinaware; and (3) a brief study of the effect on resistance to abrasion of varying glaze composition, thickness, firing treatment, and type of body used. Different brands of whiteware vary greatly in their resistance to cutlery marking, scratching, and other forms of disfiguration, known as "unsightliness." This "unsightliness" is a source of considerable loss to users of chinaware because much ware which is still mechanically serviceable is too poor in appearance for further use and must be discarded.

A number of methods for determining the "abrasive resistance" of glazes, requiring various types of apparatus, have been proposed; for example, penetration by a needle under pressure, scratching of needles, the use of abrasive wheels, the sand blast, and rotation in a cylinder with an abrasive sand. Tests using these methods are difficult to standardize, and have not been studied exhaustively in this investigation because of the greater promise of the method described by Scott. This method involves, briefly: (1) the abrasion of test specimens by dropping standard Ottawa silica sand, through a specified orifice and from a fixed height, on to the glazed surface which is set at a predetermined angle to the vertical; and (2) the measurement of resistance

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. For presentation at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.) Received November 27, 1926.

[2] "An Apparatus for Measuring the Abrasive Hardness of Glazes," *Jour. Amer. Ceram. Soc.*, **7** [5], 342–46 (1924).

by determining the weight lost by the specimen during a definite time of abrasion. This means of measuring resistance proved to be impracticable for whiteware glazes because, (*a*) unsightliness is reached before an appreciable weight is lost; (*b*) the errors in weighing large specimens by ordinary means are often comparable with the losses. The method substituted, and used in this investigation, is described later.

Early in the investigation unaccountable variations were noted in the resistance of the same glazes upon testing them on different days. Finally a series of tests extending over a period of two weeks was made on the same brand of hotel chinaware. Contemporary records of atmospheric conditions showed the resistance of the glaze to be proportional to the per cent relative humidity of the atmosphere and that temperature changes were apparently not affecting the results. Therefore, in order to maintain constant abrading conditions, the humidity in the room was kept constant and all data referred to in this paper were obtained under this condition.

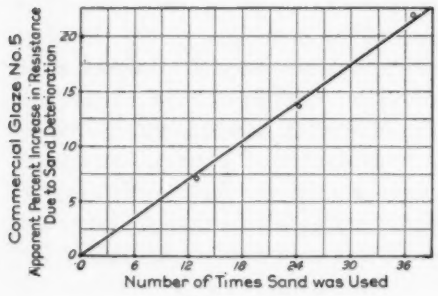


FIG. 1.

Errors of more than 3% due to wear of the sand itself were avoided by discarding that which had been used five times (Fig. 1). An attempt was made to find the cause of this decreased cutting power by comparing new sand with used sand under a binocular microscope. No difference between the sizes and shapes of the grains of the two groups could be ascertained. Possibly the dust accumulated from repeated tests has a buffering effect on the sand grains.

Apparatus Used

The Glarimeter The glarimeter (Fig. 2), an instrument used for measuring the gloss of paper, has been fully described n other publications.[1] Its function is to determine the fraction of the light (reflected from a surface) which has been plane polarized by the reflection. The percentage of plane polarized light in the total light reflected is a measure of the "gloss." While the glarimeter was not designed to measure the "glossiness" of ceramic glazed surfaces, preliminary experiments showed that the instrument gave satisfactory results. With glazed surfaces complete polarization is not attained,

[1] Central Scientific Co., *Bulletin*, No. 100, May 1, 1923. L. R. Ingersoll, "The Glarimeter, an Instrument for Measuring the Gloss of Paper," *J. Opt. Soc. of Am.*, **5**, 213 (1921).

although it may be closely approximated in some cases. Therefore, the initial gloss of each specimen was taken before abrasion and, to facilitate comparison between the abraded surfaces of various samples, the value found taken as 100%.

Abrasion Device The abrading apparatus used in this study is fundamentally the same as that described by Scott.[1] However, the use of the glarimeter for the observation of abrasion required the following alterations:

(1) The height of fall of the sand was reduced to forty inches so that abrasion would take place more slowly, thus permitting observations to be made with greater accuracy.

(2) The funnel orifice was reduced to 0.4 inch in length and 0.24 inch in width, as the glarimeter required a smaller field of abrasion than was previously used.

An inverted cone-shaped guide was placed beneath the specimen support to deliver the abrading sand into the scale pan of a spring balance since it was found to be more accurate and dependable to measure the sand used in terms of *weight*, rather than *time of flow*.

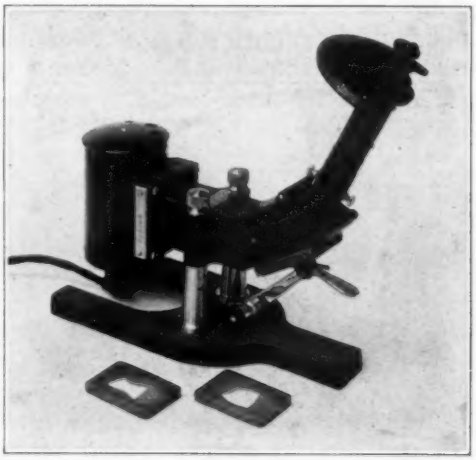


FIG. 2.—Ingersoll glarimeter and specimen supports with irregular shaped specimens mounted in metal frame in foreground.

Specimen Holders Specimen holders (sheet metal frames $2\frac{1}{2} \times 1\frac{3}{4} \times \frac{1}{4}$ inches, Fig. 2) were made so as to fit accurately in the glarimeter and abrasion device. The irregular shaped glaze specimens (approximately $\frac{5}{8} \times 1$ inch, Fig. 2) were "set" in these holders with molten sulphur, thus enabling the operator to place the specimens in the same relative position during successive abrasions and gloss-readings. It was necessary to use these small specimens in order to obtain sufficiently plane surfaces to give comparable results in the glarimeter.

Test Method

Preparation of Specimens Specimens of the material to be tested were mounted in the holders (Fig. 2) as follows: The specimens, broken from either commercial or laboratory samples,

[1] *Loc. cit.*

were placed face downward on a smooth, well-oiled glass plate, the metal frames placed over them and filled with molten sulphur. Upon cooling, the sulphur fixed the specimens rigidly. Since cleanliness is absolutely essential in making gloss determinations, the specimens were washed thoroughly with soap and hot water and dried with a towel before taking glarimeter readings.

Aligning the Apparatus The specimen support of the abrading apparatus was adjusted in such a way that the center of abrasion and the center of observation in the glarimeter coincided.

Determination of Abrasion The initial gloss of the prepared specimen was first determined and it was then abraded successively with equal weights of sand (a 0.7 kg. increment was found suitable) until the gloss was reduced[1] about 25%. The specimen was washed and dried after each abrasion, and the gloss determined. The values observed for each glaze were reduced to "percentage of the initial reading," which itself was considered as 100%; thus all glazes were placed on a comparable basis.

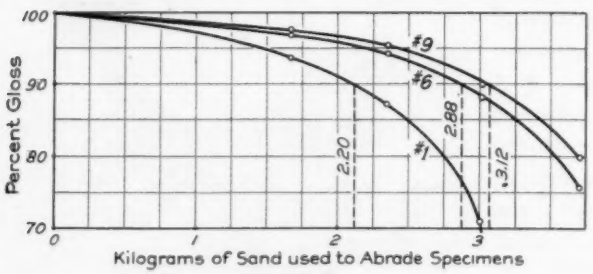


FIG. 3.

Upon plotting weight-of-sand versus per cent gloss on coördinate paper, the points fall on smooth curves as shown in the graph, Fig. 3. Over 300 curves for bright glazes, located in this way, conform to the general formula, $100-y=ax+bx^2+cx^3$.[2]

Different glazes can be compared through the constants in the above equation, which are calculated by obtaining various values for x and y (x = weight of sand, y = per cent gloss). For simplicity, a single point may be selected for comparison and in this study the point of intersection of the gloss-sand curve and the 90% gloss line (Fig. 3) was chosen for the following reasons: (1) differentiation was not always clear before the initial gloss had been reduced by approximately 10%; (2) glarimeter readings became less accurate when the gloss was

[1] The resistance of the glazes could not be determined by abrading them all with an equal weight of sand and differentiating by varying gloss because the "range of resistance" of the glazes used was too great; for instance, as in Fig. 3, brand No. 1 was unsightly before Nos. 6 and 9 were sufficiently abraded to distinguish between them.

[2] Matt and semimatt glazes approach straight line abrasion.

reduced by more than 10%; and (3) the glaze had become unsightly when its initial gloss had been reduced by 10%. Consequently, the term "resistance" as used in this report indicates the number of kilograms of sand required to reduce the gloss on the tested glaze by 10%. For example, in Fig. 3, glaze No. 1 has a resistance of 2.20 (indicated by the dotted lines), No. 6 of 2.88, and No. 9 of 3.12.

Thickness Measurement After the gloss determinations were completed, the specimens were dislodged from the holders, broken across the field of abrasion, and the glaze thickness measured at the abraded section with a micrometer microscope.

Alternate Test Method

Abrasion As sightliness is a surface factor, observations of relative resistance to abrasion can be made by visually matching abraded glazes with arbitrary standards. The standards used were prepared by abrading five specimens of glazed ware so that the first was only slightly pitted while the surface of the last was practically

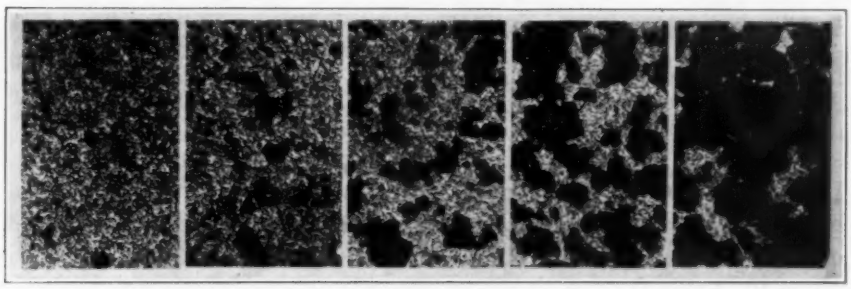


FIG. 4.—Standard scale used in the alternate method. Dark spots indicate abraded areas.

destroyed; the remaining three specimens graded equally between these extremes (see Fig. 4). They were mounted in the order of their relative amounts of abrasion and numbered consecutively from 1 to 5, No. 1 being the least abraded.

Specimens to be tested were prepared and abraded, as in the glarimeter method, and then compared with the standard scale and evaluated to correspond to the scale unit which was more nearly matched. In this manner a series of values was obtained for each glaze and its relative resistance shown by plotting scale-units versus weight-of-sand (Fig. 5).

Thickness Comparative thickness measurements were made with a scale constructed of six specimens with glazes approximately 0.05, 0.10, 0.20, 0.30, 0.40, and 0.50 mm in thickness respectively. The cross-sections of the test specimens were compared to

the scale units and each one evaluated to correspond to the unit most nearly matched. An ordinary magnifying glass was of considerable assistance in this work.

This "alternate method" could be used without the constant humidity control. However, the results obtained in this way would be relative only but probably quite suitable for plant control purposes. Also, limited research could be conducted by testing glazes in groups and finally comparing the most resistant members of each group. Sufficiently constant atmospheric conditions could be obtained by testing all the specimens of a group on the same day.

Results

1. Hotel Chinaware

Ten brands (four foreign and six domestic) of commercial seven-inch dinner plates were tested to determine the resistance to abrasion of their glazes. Five plates from each brand were selected at random and two tests made on each plate, the values reported in Table I being the average for ten determinations. Typical results are shown in Fig. 3. The maximum variation from the average between the plates of the individual brands was less than 3% in two cases, 5 to 9% in six cases, 10.5% in one case, and 13.5% in the most extreme case. In the test results reported in this paper there was less variation between the plates of the vitreous ware than the semivitreous, and two of the foreign vitreous brands showed the least variation (Brands 9 and 10, Table I).

TABLE I

RESULTS ON HOTEL CHINAWARE

Brand. No.		Initial gloss	Resistance[a] (Average for 5 plates and 10 determinations)	Max. variation from av.
		%		%
Foreign	1[b]	95.8–97.5	2.20	13.5
Domestic	2	94.5–97.5	2.45	7.5
"	3	95.4–97.5	2.55	6.0
"	4	95.4–97.5	2.62	5.0
"	5	95.4–97.5	2.73	10.5
"	6	94.9–97.5	2.88	7.0
"	7	95.4–97.2	2.88	8.0
Foreign	8	92.5–97.5	2.98	9.0
"	9	93.8–97.2	3.12	1.5
"	10	94.9–97.5	3.20	2.5

[a] Kgs. of sand required to reduce initial gloss 10%.
[b] Semivitreous.

2. Experimental Glazes

Forty-nine experimental glazes (compositions given in Fig. 6) were prepared to study the effect on resistance, of: (*a*) varying SiO_2 and Al_2O_3 content, (*b*) glaze thickness, and (*c*) firing treatment. The firing behavior of these glazes was determined by three preliminary firings to cones 6, 9, and 12. Twelve samples were selected from the group representing glazes of widely different maturing behavior and of maximum variation in both SiO_2 and Al_2O_3 content and used in obtaining the final data reported in this investigation. Their firing behavior is indicated by the data in Table II.

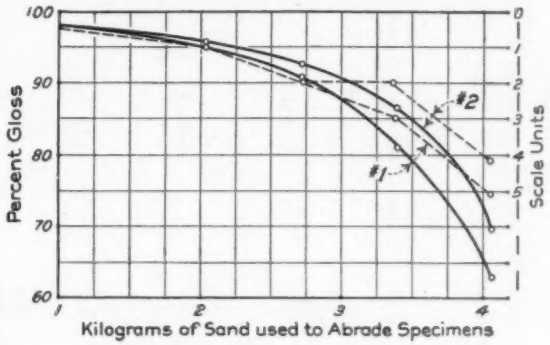


FIG. 5.

The vitreous and semivitreous bodies on which the glazes were fired were of the same composition as used by Sortwell in a previous investigation.[1] The glazed specimens were prepared by the "two-fire" process.

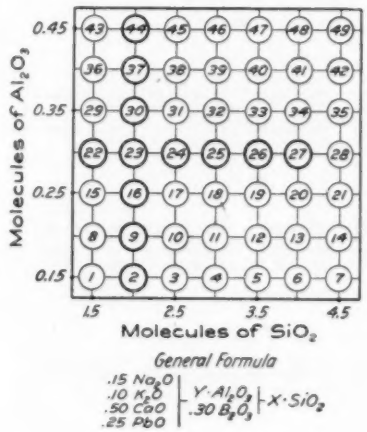


FIG. 6.

The detailed data are given in Tables II and III. Each glaze was fired on a vitreous and on a semivitreous body, and to cones 7 and 9 on each body. Each glaze was fired also in four thicknesses on each body and to each cone. Glazes 22, 23, 24, 25, 26, and 27 contained increasing amounts of SiO_2, which was the only variable (Fig. 6), and glazes 2, 9, 16, 23, 30, 37, and 44 contained increasing amounts of Al_2O_3 as the only variable.

In general there is a well-defined increase in resistance from glaze No. 22 to glaze No. 24, inclusive. With further increase in silica content (glazes Nos. 25, 26, and 27)

[1] H. H. Sortwell, "The Bonding Effect of Ball Clays in Fired Bodies," *Jour. Amer. Ceram. Soc.*, **7** [2], 75 (1924).

TABLE II

EFFECT OF VARYING FIRING TREATMENT AND TYPE OF BODY USED

Vitreous Body

SiO_2 Group

Glaze No.	Specimen No.	Glaze Thickness	Cone 7 Initial Gloss[c]	Resistance	Glaze Thickness	Cone 9 Initial Gloss[c]	Resistance	Change in Maximum Resistance[a] from Cone 7 to Cone 9	Condition of Glaze
		mm	%	(b)	mm	%	(b)	%	
	1	.10	97.0	2.45	.10	97.0	2.50		
22	2	.17	94.0	1.90	.14	97.5	2.60		
	3	.50	97.5	1.40	.30	97.5	2.30	+ 6.1	clear
	4	.30	96.5	2.10	.30	96.0	2.05		
	1	.10	96.5	2.25	.20	95.5	3.20		
23	2	.18	90.5	2.40	.15	97.0	3.00		
	3	.20	97.0	2.30	.34	96.5	2.45	+33.3	clear
	4	.24	96.5	2.10	.50	97.0	2.40		
	1	.10	96.5	2.75	.10	94.5	3.25		
24	2	.15	96.0	2.55	.20	93.0	2.90		
	3	.20	97.5	2.60	.25	94.5	2.65	+18.3	clear
	4	.24	95.0	2.50	.40	97.5	2.65		
	1	.06	95.0	2.10	.10	96.5	3.10		
25	2	.08	95.5	2.10	.20	97.0	3.00		
	3	.14	97.0	2.55	.40	96.5	2.65	+21.5	clear
	4	.18	97.0	2.55	.40	93.0	2.70		
	1	.04	95.5	2.40	.12	96.0	2.35		
26	2	.05	94.0	2.35	.26	95.0	1.90		
	3	.10	91.0	1.55	.30	94.0	2.40	+ 8.3	dull
	4	.22	96.0	2.10	.50	95.0	2.60		
	1	.18	94.5	1.35	—	—	—		
27	2	.10	88.0	0.80	—	—	—		
	3	.15	88.0	0.80	—	—	—	—	matt
	4	.48	93.0	1.55	—	—	—		
							Av.	+17.5	

TABLE II (*concluded*)

Al_2O_3 Group

Glaze No.	Specimen No.	Glaze Thickness	Cone 7 Initial Gloss[c]	Resistance	Glaze Thickness	Cone 9 Initial Gloss[c]	Resistance	Change in Maximum Resistance[a] from Cone 7 to Cone 9	Condition of Glaze
		mm	%	(b)	mm	%	(b)	%	
	1	.08	97.5	2.57	.04	95.0	3.25		
2	2	.12	97.0	2.10	.10	97.5	2.65		
	3	.22	97.0	2.30	.30	97.5	2.60	+26.5	clear
	4	.28	97.5	1.90	.40	97.5	2.75		
	1	.10	96.0	2.55	.10	95.0	3.10		
9	2	.09	97.0	2.50	.20	98.0	2.70		
	3	.18	97.5	2.20	.20	97.5	2.60	+21.6	clear
	4	.20	98.0	2.20	.30	97.5	2.50		
	1	.04	97.0	2.55	.06	95.0	3.00		
16	2	.12	96.0	2.20	.12	97.5	2.95		
	3	.20	97.5	2.10	.24	97.5	2.75	+17.8	clear
	4	.20	96.0	1.95	.55	97.5	2.00		
	1	.10	96.5	2.25	.20	95.5	3.20		
23	2	.18	90.5	2.40	.15	97.0	3.00		
	3	.20	97.0	2.30	.34	96.5	2.45	+33.3	clear
	4	.24	96.5	2.10	.50	97.0	2.40		
	1	.06	94.0	2.50	.06	96.0	3.25		
30	2	.18	96.0	2.60	.14	96.0	3.00		
	3	.15	97.5	2.45	.12	97.0	2.85	+25.0	clear
	4	.22	96.5	2.20	.30	97.5	2.85		
	1	.06	93.0	1.85	.05	87.0	1.70		
37	2	.10	95.5	2.15	.10	96.0	2.90		
	3	.20	96.0	2.35	.15	95.0	—	+36.3	dull
	4	.35	97.0	1.95	.15	96.5	3.20		
	1	.10	88.0	1.80	—	—	—		
44	2	.12	96.0	1.75	—	—	—		
	3	.20	95.5	2.00	.15	94.5	2.65	+20.4	dull
	4	.45	97.5	2.20	.16	96.5	2.65		
								Av. +25.8	

[a] Maximum resistance refers to the highest resistance obtained with any one glaze when varying the thickness but maintaining temperature of firing and type of body constant.

[b] Kgs. of sand required to reduce initial gloss 10%.

[c] Initial gloss is known to be low in some cases, due to slight curvature of specimens and other variations in the angle of incidence in the glarimeter. However, the results obtained are relative and apparently not affected by such variations.

TABLE III

EFFECT OF VARYING FIRING TREATMENT AND TYPE OF BODY USED

Semivitreous Body

SiO_2 Group

Glaze No.	Specimen No.	Glaze Thickness mm	Cone 7 Initial Gloss[c] %	Resistance (b)	Glaze Thickness mm	Cone 9 Initial Gloss[c] %	Resistance (b)	Change in Maximum Resistance[a] from Cone 7 to Cone 9 %
	1	.20	97.0	2.05	.16	97.0	2.65	
22	2	.24	97.0	1.90	.40	97.0	1.95	+29.2
	3	.40	97.5	1.80	.40	97.0	1.90	
	4	.40	97.0	1.80	.35	95.0	2.05	
	1	.08	97.0	2.55	.10	97.0	2.80	
23	2	.18	97.0	2.45	.18	95.5	2.55	+ 9.8
	3	.24	95.5	2.30	.18	97.0	2.35	
	4	.35	97.0	1.95	.35	97.0	1.70	
	1	.08	96.5	2.50	.15	97.0	2.60	
24	2	.10	96.5	2.50	.20	96.5	2.85	0.0
	3	.20	97.0	2.85	.18	97.0	2.25	
	4	.25	97.5	2.70	.18	96.5	2.30	
	1	.12	96.5	2.65	.14	97.0	2.75	
25	2	.14	95.0	2.45	.10	97.0	2.95	+11.2
	3	.24	93.0	2.55	.16	97.0	2.70	
	4	.30	97.0	2.50	.14	98.0	2.75	
	1	.06	94.0	2.05	.30	93.0	3.00	
26	2	.14	96.0	2.25	—	90.0	—	+33.3
	3	.24	95.5	2.10	—	—	—	
	4	.28	96.0	2.05	—	—	—	
	1	.08	90.0	2.05	.20	93.5	2.55	
27	2	.18	91.0	1.25	—	89.0	—	+24.3
	3	.50	93.5	1.50	—	—	—	
	4	.55	94.5	1.70	—	—	—	
							Av.	+21.6

TABLE III (*concluded*)
Al_2O_3 Group

Glaze No.	Specimen No.	Glaze Thickness mm	Cone 7 Initial Gloss[c] %	Resistance (b)	Glaze Thickness mm	Cone 9 Initial Gloss[c] %	Resistance (b)	Change in Maximum Resistance[a] from Cone 7 to Cone 9 %
	1	.16	96.5	2.60	.10	97.5	3.10	
2	2	.15	97.0	2.65	.40	97.0	2.40	+16.8
	3	.30	96.5	2.25	.45	96.0	2.40	
	4	.30	97.0	2.45	.18	97.0	2.90	
	1	.10	96.0	2.90	.10	97.0	2.95	
9	2	.10	95.0	2.80	.35	96.0	2.30	+ 1.7
	3	.28	97.0	2.70	.42	94.5	2.25	
	4	.30	97.5	2.70	.40	97.0	2.20	
	1	.14	96.5	2.55	.18	97.0	2.75	
16	2	.18	96.0	2.50	.22	95.5	2.75	+11.7
	3	.32	96.0	2.35	.16	98.0	2.85	
	4	.38	95.5	2.20	.19	97.5	2.75	
	1	.08	97.0	2.55	.10	97.0	2.80	
23	2	.18	97.0	2.45	.18	95.5	2.55	+ 9.8
	3	.24	95.5	2.30	.18	97.0	2.35	
	4	.35	97.0	1.95	.35	97.0	1.70	
	1	.10	96.5	2.75	.20	96.0	3.05	
30	2	.14	95.0	2.55	.40	96.5	2.20	+10.9
	3	.16	97.0	2.50	.35	93.0	2.85	
	4	.20	96.0	2.40	.30	97.5	2.65	
	1	.04	98.0	1.70	.40	97.0	3.30	
37	2	.14	97.0	2.50	.20	97.0	3.15	+32.0
	3	.18	97.0	2.50	.20	97.0	3.15	
	4	.20	96.5	2.45	.15	97.5	3.10	
	1	.04	92.0	2.05	.35	97.5	2.95	
44	2	.10	96.0	2.20	—	97.0	—	+20.4
	3	.10	95.5	2.15	—	—	—	
	4	.20	95.0	2.45	—	—	—	
							Av.	+14.8

[a] Maximum resistance refers to the highest resistance obtained with any one glaze when varying the thickness but maintaining temperature of firing and type of body constant.

[b] Kgs. of sand required to reduce initial gloss 10%.

[c] Initial gloss is known to be low n some cases, due to slight curvature of specimens and other variations in the angle of incidence in the glarimeter. However, the resu ts obtained are relative and apparently not affected by such variations.

there is, in general, a decrease in resistance. This may be due either directly to the increased SiO_2, or to the "immature" physical condition, of the glaze. There is no well-defined relation between Al_2O_3 content and resistance other than a decided decrease in the resistance of glazes 37 and 44, which again may be due either directly to the increased Al_2O_3 or to the "immature" physical condition of the glaze.

Of the four thicknesses used, the thinnest, or next to the thinnest, showed the greatest resistance for roughly 80% of all the glazes irrespective of the body type or glost fire. The same was true for 90% of the clear glazes. This indicates that thin glazes would have greatest resistance, which is in accord with opinions held in the industry for many years.

The data show an appreciable and consistent increase in resistance due to higher firing. For the silica group of glazes the increase, using the vitreous body (Table II) averaged 17.5, and 21.6% when using a semivitreous body (Table III). For the Al_2O_3 group the increase was 25.8% and 14.8% when using a vitreous and semivitreous body respectively.

TABLE IV

CHANGE IN MAXIMUM RESISTANCE[a] FROM SEMIVITREOUS TO VITREOUS BODY

SiO_2 Group			Al_2O_3 Group		
Glaze No.	Cone 7 %	Cone 9 %	Glaze No.	Cone 7 %	Cone 9 %
22	+19.5	− 1.9	2	− 3.0	+ 4.7
23	− 5.8	+14.8	9	−12.0	+ 5.0
24	− 3.5	+14.0	16	0.0	+ 5.2
25	− 3.8	+ 5.0	23	− 5.9	+14.2
26	+ 6.6	−13.3	30	− 5.5	+ 6.6
27	−24.4	—	37	− 6.0	− 3.0
			44	−10.2	+23.7
Av.	− 2.3	+ 3.7		− 7.1	+ 8.1

[a] Maximum resistance refers to the highest resistance obtained with any one glaze when varying the thickness but maintaining temperature of firing and type of body constant.

Effect of Type of Body The data (Table IV) indicate that the type of body used, whether vitreous or semivitreous, is a secondary factor, the controlling factors being the composition of the glaze and the temperature of the glost fire.

Conclusions

1. The glarimeter method gives fundamental results, and is sufficiently consistent to be used for research and other work which requires a high degree of accuracy.

2. The "alternate method" described for determining glaze resistance is sufficiently accurate, simple, and rapid for plant control.

3. The average resistance of the foreign ware was higher than that of the domestic and the variation from the average was, in general, less.

4. The data are insufficient to justify definite conclusions regarding the effect of varying SiO_2 and Al_2O_3 content.

5. The resistance of well-matured glazes is inversely proportional to the thickness.

6. The resistance decreases as the tendency to matt increases.

7. For the two temperatures used the resistance is markedly increased by the higher glost fire.

8. Glaze composition and temperature of glost fire affect resistance more than does the type of body used.

Remarks

Although this investigation is of a preliminary nature, a practical, dependable basis for determining glaze resistance to abrasion has been found and the data obtained indicate in a general way the influence of the several mentioned factors of glaze manufacture. The data given are applicable only to their particular cases, although the tendencies shown are probably general and should be of service to those skilled in the art of glaze manufacture. Necessarily, a tremendous amount of work and time would be required to thoroughly investigate all the factors affecting glaze resistance; therefore, this paper only purports to furnish the manufacturer with suitable means for solving his particular problems. It is hoped that those interested will continue this work, broadening the field of investigation and adapting the method to plant control. The Bureau will be pleased to coöperate with and assist such endeavors.

IMPACT AND STATIC TRANSVERSE STRENGTH OF WET PROCESS ELECTRICAL PORCELAIN[1]

By Louis Navias

ABSTRACT

Resistance to Impact A brief review is given of the apparatus used for determining the resistance to impact of ceramic materials, namely, apparatus of the "pile driver" type and of the pendulum type. A Charpy (pendulum) transverse impact machine of 2 ft.–lbs. maximum capacity suitable for porcelain has been built and is described. Specimens from ½ to 1⅛ inches in diameter can be accommodated on movable supports. Data were obtained for ½, ¾, 1, and 1⅛ inch diameter cylinders of wet process porcelain on a 4-inch span, the average values for ½-inch diameter being 1.24 ft.–lbs. per sq. in., and the average value for ¾, 1, and 1⅛ inches being 1.53 ft.–lbs. per sq. in. with an average deviation from the mean of about 2.5%.

Modulus of Rupture (static transverse) Data on specimens of wet process porcelain ½, ¾, 1, and 1⅛ inch in diameter fractured on 4- and 5-inch spans give equivalent values for the modulus of rupture. The average of all values is 11,000 pounds per square inch.

"Pile Driver" Type of Impact Machine

In the *Year Book* of the American Ceramic Society of the year 1921–1922 there was reprinted the test for "Resistance to Impact" of electrical porcelain given by the A.S.T.M. as a tentative method, serial designation D 116–21 T. The specimen consists of a disk 1½ inches diameter and 1 inch thick, the opposite sides being ground true and parallel. A hammer weighing 1.87 pounds is allowed to fall on the disk from a height of 6 inches. The test is repeated at this height of fall twenty times, when the height is increased to 7 inches for 20 blows, and so on *ad infinitum* until the specimen fractures. The apparatus is hand operated.

An automatic machine of this "pile-driver" type has been furnished by the Tinius Olsen Testing Machine Company. A continuous chain driven by a motor can be operated to lift a weight to any given height, and released automatically to fall on the specimen. The machine may be set to operate at any given height, or it may be set to lift the weight to successive heights for each fall. With these machines comparative results have been obtained for numerous materials and they are indicative of the impact resistance to successive blows. The general criticism, however, has been made that these results are not quantitative for the weakening of the specimen is made by an accumulation of blows at some particular height or by an accumulation of blows at successively increasing heights.

One concern uses the method of a falling circular weight riding on a vertical rod. The cylindrical specimen is clamped at one end in a

[1] Received December 9, 1926. For presentation at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.)

horizontal position, and the weight falls on the free end. The weight is raised manually to successively greater heights until the specimen breaks.

Pendulum Type of Impact Machine

Metals In the metal industries the pendulum type of impact machine has been in use for some years. A weight at the end of a rigid arm is allowed to swing against a specimen held in one of two ways, and the energy required to break the specimen in the first blow is determined. In the Charpy type of machine the specimen is held at both ends and the fracture occurs at the middle of the specimen while in the Izod type the specimen is clamped at one end only and the fracture occurs in the unclamped portion of the specimen. The specimen is held in a horizontal position in the Charpy machine and vertically in the Izod machine. Usually the specimen is notched with a V-groove, and this has the effect of causing the specimen to fracture through an area containing the notch. The present tendency in metal testing is to use specimens without notches.

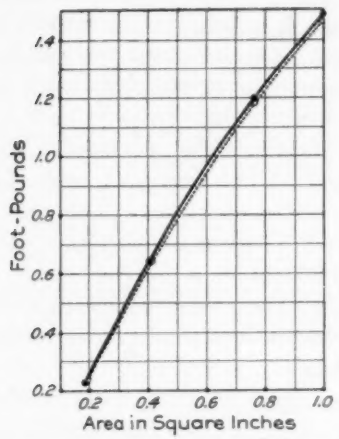
Insulating (brittle) Materials Only in recent years have modifications of the heavy machines used for metals been made to accommodate such materials as porcelain, glass, and organic molded compounds. In England and the continent both Charpy and Izod types have been in use. In Singer's[1] *Keramik* there is an illustration of a Charpy type of instrument of 10 cm. kg. (0.7 ft.–lb.) capacity. A rather similar instrument of European make with interchangeable pendulum bobs for capacities of 10 cm. kg. and 40 cm. kg. has been offered for sale in this country. The supports for the specimen consist of two metal L's and the specimen is placed to make simultaneous contact with the horizontal and vertical arms of the supports. The pendulum is allowed to swing from its highest position and come in contact with the specimen near its center. The applied energy is consumed in two distinct ways: (1) by the breaking of the specimen, the absorbed impact energy, and (2) by the swinging of the pendulum beyond the vertical plane drawn through the length of the specimen, the residual energy. As the pendulum swings beyond the original position of the specimen it causes an indicating arm to swing with it and leave it at the maximum upward position. From a scale attached, the residual energy as indicated by the pointer is read, and the absorbed impact energy is obtained by subtracting the residual energy from the applied energy.

In the United States several machines of this type have been built. There is a Tinius Olsen Pendulum Type Impact Testing Machine of

[1] Die Keramik im Dienste von Industrie und Volkswirtschaft, 421 (1923).

2.1 ft.–lbs. capacity described in their catalog as being "designed primarily to test porcelain as used in spark plugs. . . . ." "The specimen is firmly held in a vise" at one end and in an upright position.

Those interested in the field of organic molded compounds have made great strides in solving their problems of resistance to impact. Werring in a paper[1] on "Impact Testing of Insulating Materials," describes and illustrates several instruments: (1) a 7 ft.–lbs. machine of convertible Charpy and Izod types of the Ohio Brass Company and of the Bakelite Corporation, (2) a 3 ft.–lbs. Charpy type and a 2–5 ft.–lbs. variable capacity Izod type of the Bell Telephone Laboratories. The tendency has been to make smaller capacity machines, and to use notched specimens. On account of the great variety of molded compounds with the attendant large variation in resistance to impact, their problem is a difficult one. The specimen which has been practically standardized for this work is a rod 5 inches long with a square cross-section $\frac{1}{2}$ inch on a side, and with a notch at the center. The span for testing is 4 inches.



Cylindrical specimens used Length 6", span 4"

	NO. OF SPECIMENS	AVE. DIAM. INCHES	AVE. AREA SQ. IN	AVE. BREAK FT-LB	AVE. DEVIATION FROM MEAN
——●——	10	0.488	0.187	0.23	4.3%
FIRST LOT	10	0.721	0.409	0.64	4.7 "
TESTED	10	0.983	0.761	1.20	3.3 "
JULY 1926	10	1.130	1.003	1.48	0.7 "
---○----○---	10	0.495	0.192	0.24	8.3 "
SECOND LOT	10	0.724	0.412	0.64	5.2 "
TESTED	10	0.985	0.762	1.18	2.4 "
SEPT. 1926	10	1.125	0.994	1.46	1.7 "

FIG. 1.—Resistance to impact of wet process porcelain. Tests made on Charpy-type Impact Tester.

Werring has made tests on molded insulation using both the Charpy and Izod types of machines and has enumerated the advantages and disadvantages of each, and his conclusion concerning them is

> at the present writing, therefore, it appears to be difficult to justify adoption of either Charpy or Izod test to the exclusion of the other except on rather arbitrary grounds such as conveniences of specimen or the undesirability of continuing two tests. . . . .

He has shown that the velocity of impact is an important factor in the actual values obtained for resistance to impact. Where the velocity of impact is maintained constant, that is by maintaining the height of drop constant, the results obtained with different weights, that is with different initial energies of blow, are fairly uniform. However, when the velocity of impact is varied by varying the height of fall, the impact strength values for any particular material, show marked

[1] Read before the American Society for Testing Materials, 1926.

divergence, the values generally increasing with the velocity. It appears desirable, as a rule, to use a fairly high velocity.

Quite recently A. J. Amsler and Company of Switzerland have offered a "Pendulum Impact Testing Machine" of 100 cm. kg. (7 ft.–lbs.) capacity. It is a modification of their metal testing machines, and instead of indicating the residual energy, it indicates the actual energy involved in breaking the specimen on an evenly-divided vertical scale, the smallest division being equivalent to 1 cm. kg. (about .07 ft.–lb.).

Adaptation of Charpy Type of Impact Testing Machine to Ceramic Materials

After a survey of the types and examples of impact machines briefly described above, the writer has considered the Charpy machine of the Bell Telephone Company as the most desirable. Free use has been made of their drawings kindly put at the writer's disposal. One important feature not included in their instrument is the variable support for different sized specimens found of great value with ceramic materials. A photograph of the apparatus illustrates the general construction.

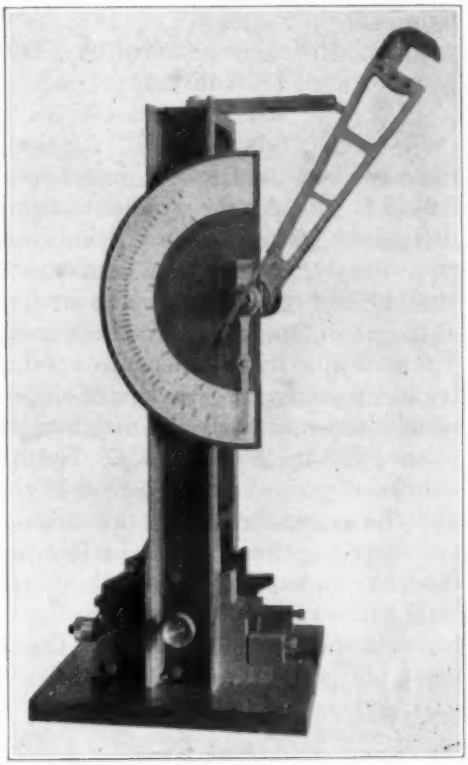


FIG. 2.—Impact Testing Machine — Charpy type.

The pendulum consists of an aluminum framework swinging in ball bearing supports, carrying a hardened steel striking bob. The length of pendulum from central support to the center of the striking edge of the bob is thirteen inches. The effective weight of the bob at the center of the striking edge is exactly one pound. The bob is allowed to fall from a height of two feet, measuring from the center of the striking edge of the bob to the horizontal plane through the center of the specimen. The applied energy is 2 ft.–lbs. and the velocity of impact

11.3 feet per second. The pendulum carries an arm which is rigidly held parallel to it, and when the pendulum reaches a vertical position, that is, when it makes contact with the specimen, the secondary arm engages an aluminum pointer which is carried to the highest point reached by the pendulum. The pointer has a light spring attached which enables it to remain in any position without falling back.

Scale The scale is made from a working drawing of a semicircle with thirteen-inch radius, the center corresponding to the center of the pendulum support and the diameter placed in a vertical direction. Horizontal parallel lines, spaced $\frac{1}{100}$ foot apart are drawn across the diameter to meet the circumference. Radial lines drawn from these intersections give a circular scale as illustrated, the radius of the scale being in this case six inches. Each division on the scale is equivalent to .01 ft.–lb., but the divisions are of unequal width, being more crowded near the middle of the scale. These values are theoretical, and correspond to those attained by a frictionless pendulum.

Friction Corrections In reality the pendulum absorbs a small amount of energy amounting to 0.035 ft.–lb. for an entire swing (about 296°). At the point of impact, the pendulum has absorbed (in friction) just half of the friction energy, namely, 0.0175 ft.–lb. As the pendulum friction is proportional to the linear drop of the pendulum, the friction between 0.0 and 2.00 ft.–lb. may be equivalently proportioned between .0175 and 0.035 ft.–lb. giving a straight line relationship. The friction in the indicator starts at zero at the time of impact and mounts to .020 ft.–lb. for a 2.00 ft.–lbs. drop. The indicator friction depends upon an angular relationship and was found by subdividing the arc of circle of the working diagram into an equal number of parts and assigning equivalent values to each angular sector (.020 ft.–lb. per 148°). The height of fall responsible for each indicator friction loss is read off at the intersection of the radial lines and the circumference of the circle. On plotting indicator friction against energy in the bob in foot-pounds, the relationship is not a straight line but shows marked divergence for low friction losses. The total friction losses of pendulum and indicator are obtained by adding together the calculated values. The values for this particular instrument are given below:

Drop Ft.-lbs.	Friction in pendulum bob Ft.-lbs.	Friction in indicator Ft.-lbs.	Total friction loss Ft.-lbs.
2.00	.035	.020	.055
1.75	.033	.017	.050
1.50	.031	.015	.046
1.25	.028	.014	.042
1.00	.026	.012	.038
0.75	.024	.010	.034
0.50	.022	.008	.030
0.25	.020	.006	.026
0.125	.019	.004	.023
0.0625	.018	.003	.021
0.0	.017	.0	.017

These values have been put on the scale for convenience. After breaking a specimen the indicated value of residual energy is added to the total friction loss for that value, the sum being the true residual energy, which when subtracted from the initial applied energy (2.0 ft.–lbs.), gives the actual energy consumed in breaking the specimen.

Before a run the pendulum is allowed to swing free, and the value attained should be 1.945 ft.–lbs., giving .055 ft.–lb. for the total friction loss. Of the two components making up the friction loss the one liable to vary is that of the indicator due to a slight tightening of the spring after continued use. It has been found convenient to maintain one set of friction loss data and reset the spring to maintain these values.

Specimen Supports (for any size test specimen between $\frac{1}{2}$ and $1\frac{1}{8}$ inches) The specimen is carried by two hardened metal L's shaped out of metal blocks which ride between parallel supports. The upper support is firmly and permanently fixed to the framework, while the lower support in the shape of a triangular wedge may be freed by loosening the screw pressing against it. (Square head-screw seen at right of photograph, Fig. 2.) The specimen support is moved by actuating a micrometer screw (divided in $\frac{1}{1000}$-inch divisions) shown at the left of the apparatus. A large knurled-head screw at the side of the supports when turned causes the specimen support to be drawn and held tightly against the uprights. For a readjustment of the specimen supports it is necessary to loosen the wedge screw slightly and loosen the knurled-head screw.

After adjustment of position of specimen by means of the micrometer screw, the wedge is tightened as well as the side screw. The supports are extremely rigid.

Each specimen support is constrained to move in a path at an angle of 26°34′ from the horizontal, which causes it to move simultaneously twice as far horizontally as vertically. Hence when a specimen with either square or round cross-section is in position for impact, it will be found when the hammer is hanging down freely (indicator at zero), that the specimen is centrally located between the upper and lower (interior) sides of the pendulum hammer and that the central point of the striking edge of the hammer is in vertical alignment and in contact with the outer edge of the specimen.

Dimensions of Supports and Striking Edge Both arms of each L are rounded to a curvature of $\frac{1}{8}$-inch radius with the arms of the L, 90° apart. The span between points of contact is four inches. The striking edge of the pendulum hammer is rounded to a curvature of $\frac{1}{8}$-inch radius, and the two sides of the wedge forming the striking edge are 45° apart. Specimens with either circular or square cross-sections can be accommodated.

Data

The results on two separate lots of specimens are given. (See Fig. 1.)

Impact Transverse
(Span 4 inches.) (See Fig. 1.)

No. of specimens	Av. diam. inches	Av. deviation from mean	Av. area sq. inches	Impact Ft.-lb.	Av. deviation from mean	Ratio of Ft.-lb. / inch (diam.)	Ratio of Ft.-lb. / sq. inch (area)
			Experiment No. 405				
10	0.488	1.2%	0.187	0.23	4.3%	0.47	1.23
10	0.721	0.7	0.409	0.64	4.7	0.89	1.56
10	0.983	0.3	0.761	1.20	3.3	1.22	1.58
10	1.130	0.4	1.003	1.49	0.7	1.32	1.49
			Experiment No. 411				
10	0.495	0.3%	0.192	0.24	6.3%	0.48	1.25
10	0.724	0.5	0.412	0.64	5.2	0.88	1.55
10	0.985	0.1	0.762	1.18	2.4	1.20	1.55
10	1.125	0.6	0.994	1.46	1.7	1.30	1.47

The data show concordant values for each sized specimen, and the averages for each set agree very closely. Calculation of the ratio between resistance to impact and the area of cross-section indicates that very similar conditions exist in the specimens of $\frac{3}{4}$, 1, and $1\frac{1}{8}$-inch diameters during the period of fracture. For Expt. No. 405 the average ratio is 1.54 with an average deviation of 2.4%, while for Expt. No. 411 the average ratio is 1.52 with an average deviation of 2.4%. The ratios for the $\frac{1}{2}$-inch specimen are lower than for the larger specimens, but agree among themselves. At present it appears reasonable to maintain that with a four-inch span specimens with diameters of $\frac{3}{4}$ to $1\frac{1}{8}$ inches will give concordant results for resistance to impact when calculated to unit area.

Static Transverse Strength (4-inch versus 5-inch span)

In the experiments conducted above the span for the impact testing is maintained at four inches. As in an earlier paper[1] tests on static transverse strength were conducted on a five-inch span it was found desirable to repeat the tests using both four- and five-inch spans. For this purpose specimens from Expt. No. 405 were used.

Static Transverse (Modulus of Rupture)
Experiment No. 405

4-inch span				5-inch span			
No. of specimens	Av. diam. inches	Modulus of rupture Lbs./sq. in.	Av. deviation from mean	No. of specimens	Av. diam. inches	Modulus of rupture Lbs./sq. in.	Av. deviation from mean
6	0.492	11,660	5.5%	6	0.491	11,165	6.3%
6	0.713	10,855	4.2	6	0.723	10,880	1.5
6	0.983	10,397	3.6	6	0.983	10,360	1.3
6	1.129	11,800	3.5	6	1.132	10,745	3.2
	average	11,178			average	10,788	

[1] "Methods of Testing and the Physical Properties of Wet-Process Electrical Porcelain," *Jour. Amer. Ceram. Soc.*, **9**, 501–10 (1926).

The values for the modulus of rupture calculated for both 4-inch and 5-inch spans are very close for the $\frac{3}{4}$, 1, and $1\frac{1}{8}$-inch specimens, the variations in each case being about $\frac{1}{2}\%$, but the values for the $\frac{1}{2}$-inch specimens vary by about 4%, the larger values being obtained for the 4-inch span test. Apart from the $\frac{1}{2}$-inch specimen, which gave rather high average deviations from the mean in both 4- and 5-inch spans, the 4-inch span test gave slightly higher deviations in modulus than the 5-inch span.

In general it may be stated that the 4-inch span and 5-inch span for static transverse strength tests give equivalent values for modulus of rupture. Or stated differently, in the equation $M=\frac{8PL}{\pi d^3}$ where $M=$ modulus of rupture, $P=$load in pounds at rupture, $L=$distance between supports in inches, and $d=$diameter of specimen in inches, for any given diameter of specimen the load at rupture is inversely proportional to the distance between supports (within the range of values of the experiment).

RESEARCH LABORATORY
GENERAL ELECTRIC CO.
SCHENECTADY, NEW YORK

A LABORATORY APPARATUS FOR THE REFINING OF PACIFIC NORTHWEST KAOLIN[1]

By Roland Joseph Clark

ABSTRACT

A review of the clay purification methods which are used at the present time is given, together with a description of a simple laboratory continuous clay-washing plant composed of a screw feed, a rotary blunger, sand separator, cone-bowl classifier, and settling tanks. The methods of operation with a sample of Pacific Northwest kaolin and the results obtained are described.

Refining Methods

The wet method of refining kaolin has been proven applicable to purification in nearly all cases. The method consists of three principal operations, namely: blunging or dispersion in water, flotation, and dewatering. The object in blunging is thoroughly to disintegrate the kaolin, thus freeing the impurities bound up or enveloped by the agglomerated clay particles. In practice about 90% of water to 10% dry refined kaolin, is used. More water is sometimes added during the process of flotation. A few of the common types of blunging machines in use are, paddle blungers, tube mills, and log washers.

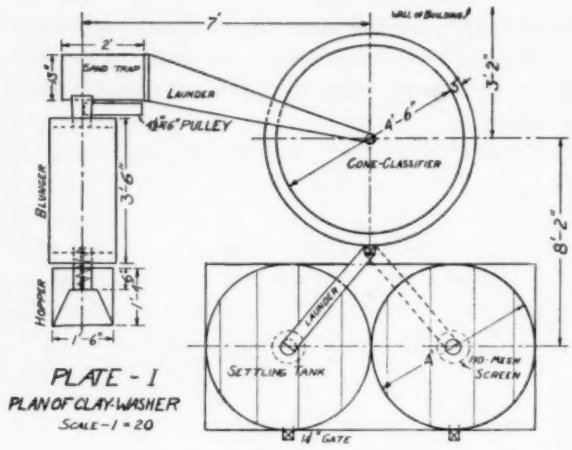


FIG. 1.

As the clay slip flows out of the blunger the very coarse particles of sand immediately settle to the bottom of a tank or a deep trough provided for it, while the suspended clay and the finer impurities continue in the process of flotation. The sand can be continually removed from the tank by means of a sand-wheel, a screw conveyer, or a drag. In the Dorr type of clay-washing equipment all of the granular impurities are collected in the bottom of a hydro-separator; thence this residue is pumped to a Dorr bowl-classifier where it is freed from all remaining clay before being discharged. The reclaimed

[1] A portion of a thesis submitted for Master's Degree in the University of Washington, 1926. Published by permission of the Director, Bureau of Mines, Department of Commerce. For presentation at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.) Received December 1, 1926.

clay slip is then pumped back into the hydro-separator which allows only the gritless clay slip to overflow into the launder leading to the settling tank.

In England the kaolin is mined and blunged in a single operation. The kaolin is sluiced out of its deposit by powerful hydraulic jets, and floats with the water into a sand-pit where the coarsest impurities settle out. The clay slip with all of the fine, suspended materials is pumped from the pit into float-troughs, while the sand is removed with drag-line conveyers and dumped outside of the clay-workings. This method is employed at the china-clay works in Cornwall and Devon by the English China-Clays, Limited.

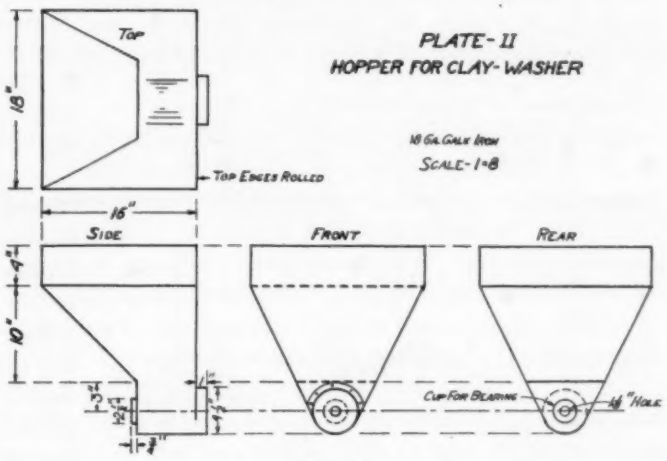


FIG. 2.

The third operation, that of dewatering the purified slip, is brought about by any one of several methods, or by a combination of methods. The English china clays are dewatered by a combination of settling, decantation of the supernatant water, and final drying of the thickened slip in shallow brick tanks heated by a system of flues built underneath. Instead of using artificial heat for final drying, the concentrated clay slip may be floated into shallow tanks exposed to the heat of the sun. Results from this method are often delayed by weather conditions and the clay is always in danger of being polluted by wind-blown impurities.

Settling-out of the clay to the consistency of a thick slip requires much time, especially in the case of very fine-grained clays. A suitable acid or salt is often added to the clay slip to cause the clay particles to coagulate and precipitate out of the suspension. This practice greatly decreases the time required to concentrate the slip. When clay has been so treated it often causes difficulty in the attainment of the proper casting consistency of the body-slip in which the clay is used. Some clays after coagulation and drying can be reblunged only with

difficulty. To avoid this trouble it is good practice to add enough alkali, after the slip has been concentrated, just to neutralize the acid.

The next usual step in the process of dewatering the clay is filterpressing. The ordinary type of recessed-plate filterpress is generally used. The pressed clay contains in the neighborhood of 35% of water.

Another machine performing a duty similar to that of the filterpress is the electrophoresis machine, the invention of Count Schwerin of Germany.[1] The essential parts of the machine consist of a metallic drum anode, which slowly rotates in a tank containing the grid cathode. As the deflocculated clay slip is fed into the tank, the clay particles, carrying an intensified negative electrical charge due to the addition of an alkali during the blunging operation, are drawn to the anode and there deposited as a layer of clay. As the anode rotates the layer of clay is removed from the surface of the drum by a scraping knife called the "doctor" and is then conveyed to the drier. Unlike the clay entering the filterpress, the slip entering the electrophoresis machine is in the dilute, unconcentrated state. The clay delivered from the machine still retains about 35% of water.

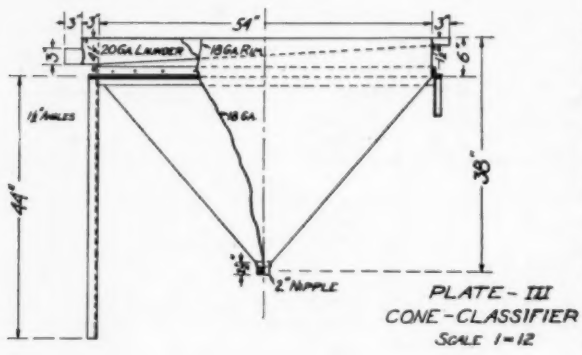


FIG. 3.

For final drying the filterpress cakes or the clay from the electrophoresis machine may be stacked on racks in the drying room or may be slowly conveyed through a tunnel drier on cars. Sometimes final drying of the clay is done by passing the damp clay through a rotary drier similar in principle to the cement kiln. The heated rotary-drum or disk type of drier is not extensively employed in the ceramic field. In operation of this type of drier the concentrated clay slip is sprayed into a tank in which the lower half of a steam-heated, metallic drum rotates. The clay adheres to the heated surface of the drum and becomes dry as the latter slowly makes one revolution. The dry layer is removed from the drum by the "doctor." This type of drier eliminates the use of the filter-press.[2]

[1] S. R. Hind, "A Visit to the Osmosis Plant at Carlsbad," *Trans. Ceram. Soc.* (Eng.), **24**, 73–75 (1924–25); W. R. Ormandy, "Electrical Process for the Purification of Clays," *Trans. Ceram. Soc.* (Eng.), **12**, 36 (1912–13).

[2] W. H. Walker, W. K. Lewis, W. H. McAdams, Principles of Chemical Engineering, McGraw-Hill Book Co., New York, 1923. Pages 347, 491–93.

Scope of the Present Work

This study was intended to deal primarily with the development of a method for refining a typical northwestern kaolin. The sample supplied for this study was mined at Mica, Washington, and is in all appearances representative of one type of the extensive kaolin deposits located in eastern Washington and northwestern Idaho.

After completion of preliminary tests on the kaolin, an apparatus suitable for washing quantities of it was built. The products obtained from the washing tests were collected and tested to determine their physical properties.

Examination of the Kaolin

In the large sample of kaolin supplied for this study two extreme types were represented. There was also an intermediate type made up of a combination of the extremes. In one extreme kaolin was decidedly the dominant mineral constituent. In this type the only other visible minerals were quartz and muscovite both of which occurred in small grains only. The other extreme type showed an excess of quartz and muscovite over the kaolin. The quartz was of the smoky variety and was present in grains of about six-mesh and finer. Grains of incompletely altered feldspar were abundant. The feldspar was white in color and quite friable; it could easily be fractured by the pressure from one's fingernail. The amount of the one extreme type was not in excess of the other, considering the sample as a whole.

An occasional piece of the kaolin shows yellowish-brown, ferruginous stains. The stains may be due to colloidal iron carried by percolating water from the basalt, which once overlaid the granite, down into crevices of the rock. There is also the probability that the iron stains are the weathered products of ferruginous minerals original to the granite.[1]

Some of the sandy residue washed from the kaolin was tabled on a small concentrating deck, revealing the presence of a small number of fine grains of heavy, ferruginous minerals such as pyrite, magnetite, and tourmaline.

A few of the specimens showed the presence of brownish veinlets of plant roots. There were also some black splotches which appeared to be due to carbonaceous matter; however, after some pieces had been fired in the test kiln the black splotches failed to disappear but changed to a manganese brown. The clay particles themselves are in an extremely fine state of division.

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[1] E. Weinschenk, The Fundamental Principles of Petrology, (translated by Johannsen), Chapter 5 and pp. 149, 150. McGraw-Hill Book Co., Inc., New York, 1916.

A Continuous Clay-Washing Apparatus

The apparatus about to be described was built on a small enough scale for convenient operation in the laboratory, and yet large enough for the results shown in its operation to be easily conceived on a commercial scale. It consists of all the essential parts required to perform the three principal steps relative to clay-washing, namely, blunging, flotation, and partial dewatering or concentration.

The blunger consists of a fir tank in the shape of a tube-mill. On the inside the tube is 16 inches in diameter and 36 inches in length. Crushed kaolin may be fed into the tube from the hopper by means

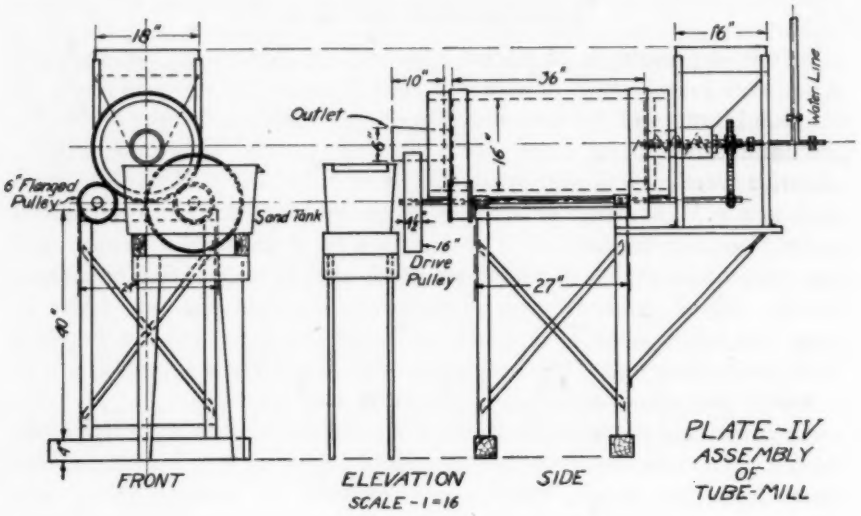

FIG. 4.

of a screw which rotates in a 4-inch galvanized pipe, connected to the hopper and leading into the blunger. The screw is driven by a pair of sprockets, one of which is mounted on the trunnion of the screw, and the other on one of the two bearing shafts of the blunger. The feed-screw is built on a hollow trunnion, through which a $\frac{3}{8}$-inch pipe delivers the water required for blunging the kaolin. The amount of water flowing into the blunger may be gaged and regulated by a system of cocks and a valve.

The tube is banded near each end with a double layer of $3\frac{1}{4}$-inch belting. The belting serves as traction to the four 6-inch bearing pulleys. Two of these pulleys are flanged to prevent end-thrusting of the tube. One of the two bearing-shafts carries a 16-inch pulley connected by a belt to a Reeves variable speed transmission.

The tube contains a small charge of flint pebbles ranging from 1½ inches in diameter to about 3 inches, for the purpose of giving effective blunging to the clay.

A 5-inch discharge hole in the center of the head of the blunger is connected to a discharge-bell which flares out to a diameter of 6 inches and is 10 inches long.

Temporarily, a rectangular tank, 13 by 24 inches in area and 13 inches in depth, serves as a trap for catching the quickly settling impurities discharged from the blunger. A launder leads from the trap to the central inlet of the cone-classifier. The latter inlet is designed to give the inflowing slip a horizontal flow that is equal in all directions from the center of the cone.

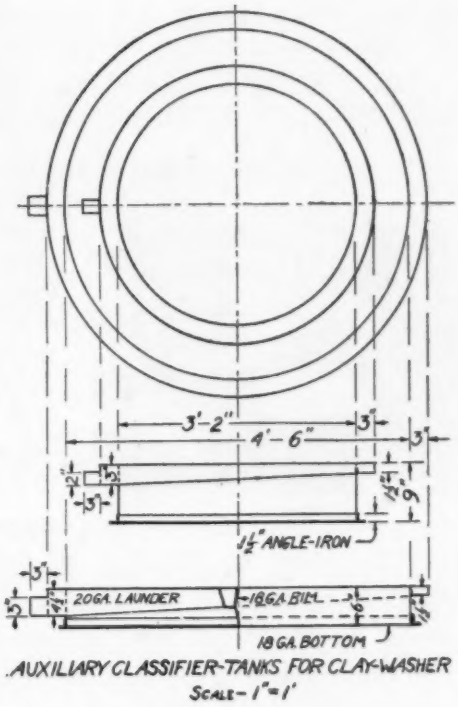

FIG. 5.

The final separation of the clay from its impurities takes place in the cone-classifier. The latter consists of a cylinder 6 inches deep by 4½ feet in diameter. This cylinder is superimposed upon an inverted cone, the apex of which is 3 feet below the junction of the cone with the cylinder. A 2-inch discharge valve is located at the apex of the cone so that the residue may be periodically discharged. The overflow of the classifier is the upper edge of the 4½-foot cylinder which may be kept level by adjusting the 2-inch belt about the circumference of the cylinder. A peripheral launder carries the slip from the overflow of the classifier to an outlet spout. The volume of the cone-classifier is 179 gallons.

A small launder connects the outlet of the classifier with a screen and either one of the two 250-gallon settling tanks. (See Figs. 1, 2, 3, and 4.)

Clay-Washing Test No. 1

Preparation of the Sample The room-dried kaolin was hand-picked and the small amount of iron-stained pieces discarded. The selected kaolin was crushed between rolls to a fineness ranging from 6-mesh to dust.

Arrangement of Apparatus A preliminary run was made for the purpose of regulating the apparatus and putting it in a satisfactory working condition. The transmission was set to turn the blunger at a velocity of 15 revolutions per minute. The feed-screw was then rotating at 10.7 revolutions and was delivering four pounds of clay per minute to the blunger. The water valve was set to deliver 5.65 times as much water as clay; that is, the weight ratio of clay to water was 15 to 85.

Clay was fed into the hopper and the blunger was run until the cone-classifier was filled with slip to the point of overflowing. The slip was allowed to remain undisturbed until the next day.

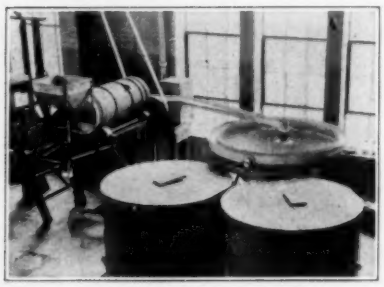

FIG. 6.

A 100-mesh screen was placed between the launder, from the cone-classifier, and the settling tank in order to arrest any floating materials before they entered the settling tank with the washed clay.

Operation The hopper was kept about half full of crushed kaolin while the blunger was operating at the predetermined rate. Tests of the blunged materials being discharged from the blunger showed the presence of only the slightest amount of undigested kaolin.

In sixty minutes after the test was started the 250-gallon settling tank was within one inch of being full with clay slip. At this time the hopper was empty. The blunger was then stopped and the water was turned off.

Several hours later a shallow sediment was found to have settled to the bottom of the tank. After a sample of the sediment was taken rapid coagulation of the clay was effected by the addition of 150 cubic centimeters of hydrochloric acid having a specific gravity of 1.135 and containing 26.7% of HCl.

After twenty-four hours the clear supernatant water was siphoned off and the remaining slip in the settling tank was thoroughly agitated. The material that had formed the sediment did not settle out again in the thickened slip.

Results of First Test 1. In one hour 240 pounds of kaolin had been fed into the blunger, with the screw having an average feeding rate of four pounds per minute or .374 pounds per revolution.

2. The first sample of slip taken from the overflow outlet of the cone-classifier had a specific gravity of 1.020. The second sample, taken near the end of the run, had a specific gravity of 1.018. The two samples were evaporated to dryness and found to contain 5.5 and 4.5% of clay respectively.

3. In twenty-four hours, after the first supernatant water was decanted, the remaining slip had a specific gravity of 1.083 and a clay content of 14.6%. After one week the clay had settled to a concentration of 20%, but the slip had been disturbed several times in the meantime.

4. Calculating from the percentage of clay in the slip and the total volume, it was found that the yield of refined clay from the kaolin fed into the blunger was 31.2%.

5. Examination of the residual impurities showed that a considerable amount of clay had also settled out due to its insufficient dispersion in the water.

Neutralization of the coagulated clay slip is important inasmuch as it renders the subsequent reblunging of the dried material a much more simple matter. A one-inch cube of acidulated, dry clay slaked down in still water in thirty minutes but the slaked material remained granular even after vigorous agitation. A similar test on the neutralized clay required one hour for complete slaking but the disintegrated material was very fine and milky. After being stirred the neutralized clay became completely dispersed in the water and remained suspended indefinitely.

A sample of the neutralized clay was sent to the Inland Empire Paper Company to be tested for its possible use as a paper filler. The following is quoted from this Company's report regarding the results of the test:

> We think you have done very well with this clay as it apparently has all the properties required in the manufacture of paper using filler. You not only removed the grit practically but the retention is good as is usual with clay. This clay also has the soapy, lustrous properties desirable.

Regarding color of northwestern china clay in the raw, dry state, it should be noted that it has a cold, greyish-white tone. During the drying of the filterpress cakes of this sample a yellow efflorescence accumulated on the exposed surfaces. The source of the trouble was traced to the settling tank. Pitch leached out of the fir, became coagulated with the clay after the addition of the acid, and later effloresced as a soluble salt.

Clay-Washing Test No. 2

Preliminary tests performed on the kaolin showed that the addition of a small amount of alkali during blunging made remarkable differences. Some of the results noticed were greater ease in blunging the crude kaolin, and a more rapid settling-out of the impurities leaving a sharp line of division between the suspended clay and its impurities. For these and other reasons it was concluded that complete deflocculation of the clay particles could not be obtained by blunging alone and that a considerable amount of the flocculated clay particles would settle with the impurities if a grit-free product were obtained. The object of this test was therefore based on the above results and conclusions.

Procedure and Results

Arrangement of the apparatus for this test was similar to that of Clay-Washing Test No. 1. The blunger contained the same charge of flint pebbles and it was set to rotate at fifteen revolutions per minute. At this rate 3.75 pounds of crushed, crude kaolin were being fed into the blunger per minute. This figure was lower than in the previous test because the kaolin in this case was more finely crushed.

An alkaline solution was prepared containing 0.163% by weight of NaOH. The solution flowed at a constant rate from a spigotted container into a funnel connected to a $\frac{1}{4}$-inch pipe leading into the center of the blunger.

The valve on the water line was set to deliver 17.94 pounds of water per minute. Also 1.98 pounds of water per minute were added by the introduction of the alkaline solution. The total amount of water used in blunging was therefore 19.92 pounds per minute. The clay-water ratio was then, 3.75 pounds of clay: 19.92 pounds of water, equalling 18.8 : 81.2; or the amount of water used in blunging was 4.32 times the weight of clay being fed into the blunger.

The slip being discharged from the blunger was completely disintegrated. The residue which settled in the quartz tank was entirely free from adhering clay.

In seventy minutes after the time of starting the cone-classifier had become filled and just started to overflow. At this time the apparatus was stopped. Up to this time 249 pounds of clay had entered the blunger. The slip in the cone-classifier was allowed to remain undisturbed for three hours in order to allow impurities to settle and to allow the eddy currents to die.

Operation was resumed and continued for 69 minutes during which time 273 pounds of clay was fed into the blunger. This made a total of 522 pounds of clay in 139 minutes.

The slip remaining in the cone-classifier was allowed to remain standing for twenty hours and was then siphoned into the second settling tank. The mica and other impurities remaining in the apex of the cone-classifier were very fine-grained and on examination were found to be practically free of clay.

The slip in the settling tanks was thoroughly agitated and samples were taken to determine clay content. Two one-liter samples of the slip were weighed and the specific gravity was found to be 1.0336. The slip was then evaporated to dryness and found to contain 6.7% of solid material. The nature of the solid material in the slip was determined by allowing two liter samples of the slip to stand undisturbed for 24 hours. The supernatant slip was then decanted, evaporated to dryness and weighed. The residue was treated likewise. The figures obtained show that the refined material contains 75.2% of finely divided clay which remained suspended in the slip for 24 hours. The remaining 24.8% consisted of a residue of gritless material composed of coarse clay particles and very finely divided flakes of muscovite or sericite mica.

The mica could be easily distinguished from the clay when examined under a microscope having a magnification of thirty diameters.

The total amount of NaOH used for deflocculating the total amount of clay treated was .448 pounds. This gives .0857% of NaOH on the basis of dry crude kaolin.

The correct amount of hydrochloric acid was added to the slip to just neutralize the NaOH used for deflocculation. The clay began to coagulate very slowly after neutralization.

Based on the weight of the crude dry kaolin the yield of refined clay was 38.4%.

Conclusions

The addition to the crude clay during the blunging process of alkali solution (not in excess of .1% in terms of crude dry clay) gives a decided advantage in purification of the clay by subsequent flotation. The yield of refined clay was 38.4% in this experiment in which the slip was deflocculated as compared to a yield of 31.2% from the experiment in which complete deflocculation was not obtained.

Due to the effect of the alkaline solution in reducing the viscosity of the clay slip the impurities settled out with greater ease. This fact makes possible the employment of a smaller amount of hydraulic water required for blunging and flotation. In Test No. 1 the clay-water ratio was 15 : 85 while in this test the ratio was increased to 18.8 : 81.2.

Summary

1. An examination of an average sample of the clay from Mica, Washington, showed, besides kaolin, an abundance of quartz grains,

a large quantity of small flakes of muscovite, some partially decomposed feldspar, and a small amount of ferruginous impurities.

2. An apparatus suitable for washing quantities of the kaolin was built. At the present time the minimum feeding rate of the hopper is 240 pounds of crushed kaolin per hour. At this rate of feed only a small amount of exceedingly fine-grained mica will pass with the clay into the settling tank during flotation.

For the convenience of greater flexibility in operation the speed of the feed screw should be variable, and independent of the velocity of the blunger.

3. Washing tests made on the kaolin with this apparatus show that from 30 to 38% of the crude kaolin consists of recoverable china clay. If the highest yield of a gritless clay is desired it is advisable to deflocculate the slip previous to the process of flotation.

4. The refined kaolin is a fine-grained, exceedingly plastic clay having a rather high shrinkage and high mechanical strength. It is suitable for use as the total clay content of pottery of the whiteware type, and it possesses all the properties required in the manufacture of paper using filler. For the latter use it is not quite as white as it should be to make the best filler.

Acknowledgment

The contents of this paper represent an account of part of the work performed by the author while holding a fellowship in ceramic engineering at the Northwest Experiment Station of the United States Bureau of Mines in coöperation with the College of Mines of the University of Washington.

Acknowledgment is gladly extended to members of the local staff of the Bureau and College of Mines and especially to Hewitt Wilson under whose supervision this work was carried on.

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THE PROPERTIES OF REFRACTORIES IN THE METALLURGY OF ZINC[1]

Part I. Raw Materials and Body Mixtures Now in Use

By E. S. Wheeler[2] and A. H. Kuechler[3]

ABSTRACT

A study has been made of some of the properties of clays, grogs, and body mixtures used by various zinc smelters for the manufacture of zinc retorts. Only minor differences were observed in the properties of the clays. No attempt has been made to offer any of the results as conclusions. The investigation tends to confirm the following points; that the use of reclaimed retort material in the grog for new retorts is of doubtful economy; that, if old bricks or shapes are used as grog, care should be taken that they were originally made of good quality clay and that they are free from slag; that some flint clay of good quality and properly calcined is advisable for at least a part of the grog; and that zinc in a clay or body mixture markedly affects the refractoriness by lowering the deformation value.

Introduction

The average zinc smelter contains from 4,000 to 5,000 retorts. The retorts are in continuous use and last from 30 to 75 days, depending upon their quality, kind of ore charged and fuel used, and on the type of retort furnace. The life of the retorts is important not only because of their first cost but also because of an important zinc loss due to absorption of zinc by new retorts, and because of the 24 hours of lost capacity before a new retort is charged.

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[1] Published by permission of the Director of the U. S. Bureau of Mines as coöperative work between the Bureau of Mines, Department of Commerce, and the Missouri School of Mines and Metallurgy.

[2] Research Metallurgist, Missouri School of Mines and Metallurgy.

[3] Junior Metallurgist, U. S. Bureau of Mines.

Note: The authors are greatly indebted to B. M. O'Harra, who outlined the investigation, and directed the major portion of the work; to H. M. Lawrence for his supervision in completing this phase of the investigation; to G. A. Bole for his interest and advice, and to the various zinc smelters and producers, who have interested themselves in the work and who have furnished some of the material used. The authors are also indebted to O. W. Holmes and Wm. Kahlbaum, coöperative chemists of the State Mining Experiment Station of the School of Mines and Metallurgy of the University of Missouri for the careful and complete chemical analyses that were required.

The conditions that a zinc retort must meet are exceedingly rigorous. The retort is about 8 inches in internal diameter, has walls about one inch thick, is from 50 to 60 inches in length, and is supported only at the two ends. Besides its own weight, it carries a load of about 100 pounds of zinc ore and fuel distributed uniformly over its length. It is heated to about 1400°C on the outside.[1] During discharging and recharging it is subjected to mechanical shocks and strains of no small magnitude. It must, therefore, possess high tensile strength, resistance to deformation, and resistance to shock.

Ordinarily the hot charge is blown out by the steam generated from a stream of water directed to the back end of the retort. While yet at a yellow heat the retort is filled with cold damp charge. The retort is exposed to corrosive slags at high temperatures. The retort must be impermeable to the zinc vapor and the furnace gases. Absorption of zinc should be as low as possible. The retorts must therefore be designed to withstand sudden temperature changes, be resistant to slags, and be impervious to zinc and furnace fumes.

There is a lack of knowledge concerning the physical and chemical properties of the clays and grogs now used for the manufacture of zinc retorts. Some research has been done, but the ground covered has not been the same as here reported.

Scope of the Investigation

Endell and Steger[2] write in part as follows:

> The furnishing of zinc retort clay capable of meeting all logical requirements will be possible only by testing various clays in practical operations. This can be done much more rapidly and easily by starting with a known zinc retort clay and determining its properties.
>
> * * * * This preparatory work is greatly simplified by beginning with clays which experience has indicated to be especially adapted to the manufacture of zinc retorts.

This expresses concisely the object of the first or analytical part of this investigation, that is, the determination of the more important physical and chemical properties of the refractory materials now being used at a number of the representative zinc smelters for the manufacture of retorts. Such data will be a guide in the further work. In the second and third sections of the investigation, to be reported at a later date, the properties of various grogs and clays, which might be suitable for the manufacture of retorts, are to be studied.

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[1] Corresponding to a temperature of 1250 to 1300°C on the inside.

[2] K. Endell and W. Steger, "Some Recent Tests of Zinc Muffle Clay and Zinc Muffles," *Metal u. Erz*, **20**, 321–33 (1923).

Materials Used

The samples collected consisted of clays, grogs, and body mixtures as follows:[1]

Clays (1) St. Louis clay, (2) Grandview clay (St. Louis), (3) St. Louis clay, (4) St. Louis clay, (5) St. Louis clay, (6) St. Louis clay, (7) St. Louis clay, (8) St. Louis clay, (9) Mine-run Cheltenham clay (St. Louis), (10) Cheltenham clay, (St. Louis from lower portion of vein, pot clays removed).

Grogs (1) One-half volume reclaimed condenser material from jig and one-half volume calcined fireclay material from around plant, (2) adobes of Grandview clay and broken retorts from tempering kilns, (3) one-third volume calcined clay and two-thirds volume used and tempered retorts, (4) one-third commercial adobes, one-third calcined Colorado flint clay, and one-third broken bricks (mixed in our laboratory), (5) calcined clay (crushed in our laboratory), (6) one-half reclaimed material and one-half calcined Maryland flint clay, (7) two-fifths adobes (St. Louis clay), two-fifths old retorts, and one-fifth old bricks, (8) broken saggers (crushed in our laboratory), (9) calcined flint clay (crushed in our laboratory), (10) calcined Cheltenham clay (crushed in our laboratory).

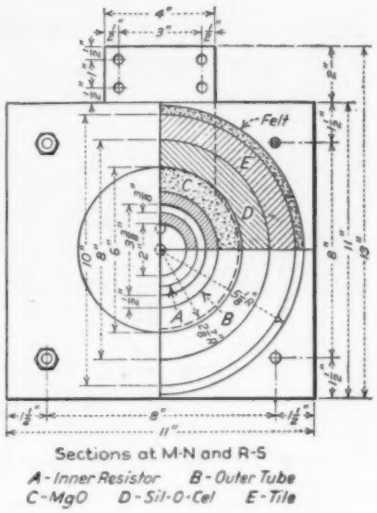

FIG. 1.—Electric Gran-Annular Carbon Resistor Furnace (plan).

Body Mixtures[2] (1) Seven parts clay and 8 parts grog by volume, (2) 5 parts grog and 4 parts raw clay by volume,

[1] The materials used in this investigation were collected by G. S. Brewer, Assistant Fuel Engineer, and Wm. E. Rice, Computer, of the U. S. Bureau of Mines, in the course of their visits to the various coöperating zinc smelters. Samples of the clays and grogs were taken from smelter stock piles, and ballots from the mix extruded by the final pugging machine were secured for samples of the body mixtures. All of these materials are in use or suitable for use in the manufacture of retorts. Clays Nos. 9 and 10, grogs Nos. 9 and 10, and body mixture No. 10 bear no relation to one another but were samples of material submitted by one of the clay producing companies. Body mixtures Nos. 1 to 8 inclusive were supposedly prepared from the correspondingly numbered clay and grog, *i.e.*, body mixture No. 1 was prepared from clay No. 1 and grog No. 1. In several body mixtures the proportions of clay and grog are given by volume rather than by weight, as this is customary practice at some zinc smelters.

[2] The proportions given are as stated by the plants visited.

(3) 52 parts grog and 48 parts clay by volume, (4) 10,000 pounds of clay to 12,500 pounds of grog, (5) one-half clay and one-half grog, (6) 7 parts of clay to 9 parts of grog by volume, (7) 45 parts St. Louis clay by weight to 55 parts of grog by weight, (8) equal volumes of clay and grog, (10) prepared body.

Laboratory Procedure

Unless otherwise noted, all tests were made according to the standard methods of the American Society for Testing Materials and the AMERICAN CERAMIC SOCIETY.

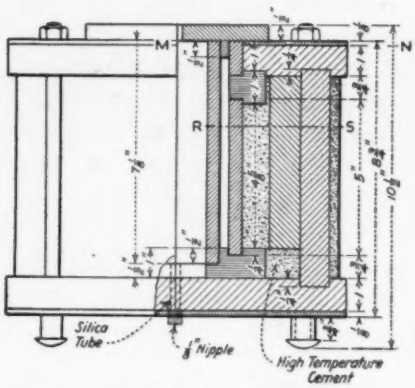

FIG. 2.—Electric Gran-Annular Carbon Resistor Furnace (elevation).

Chemical Analyses Samples of all clays, grogs, and body mixtures were portions of the samples taken for the deformation value determination but ground in an agate mortar to pass a 100-mesh sieve. The results are shown in Tables I, III, and V. In case of the grogs, zinc was run, and the carbon content was determined on body mixture No. 10 which was known to contain crushed coke.

Screen Analyses A screen analysis was run on all grog samples using Tyler standard sieves. A sample of each grog (approximately 1,000 grams) was shaken in a nest of sieves on a Ro-tap machine for 15 minutes.

Deformation Value The samples for this test were crushed to 4-mesh and finer in a jaw crusher, then coned and quartered to the amount required, and finally ground in an agate mortar to pass a 65-mesh sieve. Care was taken to prevent excessive reduction of the fines by frequent removal through the sieve.

For the deformation value determinations a gran-annular resistance furnace[1] was used, drawings of which appear as Figs. 1 and 2. This furnace was used on one phase of a 3-phase 220-volt a.c. circuit. It was connected in series with 2200-220 volt transformers, a voltage regulator, and panel board allowing a voltage variation from 17 to 300 volts, giving a very accurate temperature control.

[1] Known as the Electric Gran-Annular Carbon Resistor Furnace designed by C. H. Fulton and W. A. Coursen and described by Zay Jeffries, *Met. and Chem.*, **12**, 154(1914).

A hole in the bottom of the furnace gave rise, by natural draft, to a circulation of air, which maintained an oxidizing atmosphere around the cones, but did not cool the furnace appreciably.

The rate of heating after 800°C was approximately 10°C per minute. The deformation value of a cone was taken to be when its tip touched the plaque. It is reported as the serial number of the standard pyrometric cone which concurrently deformed.

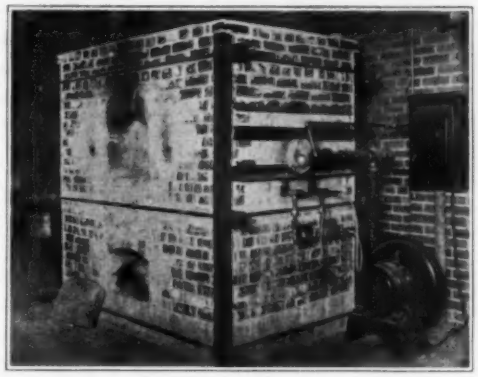

FIG. 3.

Drying Shrinkage The clays were crushed to pass a 20-mesh sieve and thoroughly kneaded with water to a mixture of soft plastic consistency. This test was also used on body mixtures except that they were not crushed before working with water. The test pieces were then formed in a steel mold measuring $1\frac{1}{8}$ by $1\frac{1}{8}$ inches, and cut into $1\frac{7}{8}$-inch lengths.

The plastic volume was then determined in a Schurecht overflow volumeter. Kerosene was used as the immersion fluid and the volume was read to the nearest 0.1 cc. After determining the plastic volume the film of kerosene on the test pieces was removed with a cloth and the pieces dried at room temperature for 24 to 36 hours, then at 64 to 76°C for at least 5 hours, then at 110°C to approximately constant weight. They were cooled in a desiccator, then soaked in kerosene for 12 hours, and the dry volume obtained.

FIG. 4.—Small transverse testing machine.

Water of Plasticity The test pieces were like those used in the shrinkage tests. They were weighed to an accuracy of 0.1 gram.

Firing Behavior The kiln used (as shown in Fig. 3) is oil-fired and has a remarkably uniform temperature distribution. The heat treatment was measured by both Orton cones and a thermo-element connected to a Leeds and Northrup recording potentiometer. The heat treatment, however, was reported in terms of cones. The heating rate was approximately 50°C per hour. Test pieces were drawn at 800°C, cones 6, 8, 12, 14, and 16, and immediately immersed in hot sand to prevent too sudden cooling.

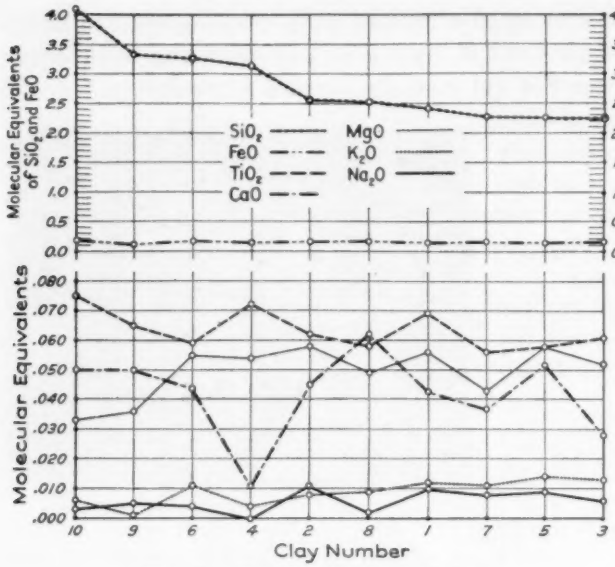

FIG. 5.—Chemical analyses of clays.

When cool enough to handle, the test pieces were put into a desiccator to cool to room temperature and weighed on a balance to an accuracy of 0.1 gram. They were then boiled for two hours in distilled water, and again weighed. The fired volume was determined in an overflow volumeter. Absorption, porosity, volume change, bulk and apparent specific gravity were calculated by the standard method.

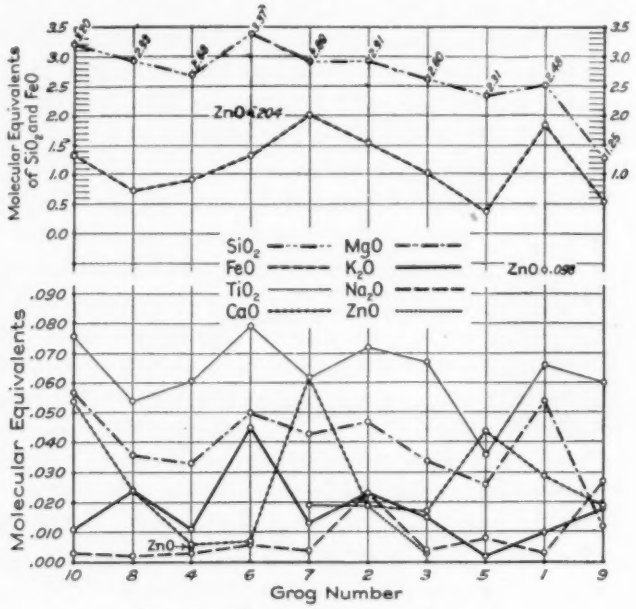

FIG. 6.—Chemical analyses of grogs.

Transverse Strength

(*a*) *Clays.*—The samples were crushed to pass a 20-mesh sieve and intimately mixed with an equal amount by weight of standard silica sand, sized to pass a 20-mesh and retained on a 35-mesh sieve. The mixture was brought to a soft plastic consistency with water, formed in a steel mold 1 by 1 inch in cross-section and 7 inches in length.

The test pieces were dried by the standard method described before, care being taken to keep the drying uniform in the early stages by turning every 12 hours.

The test pieces were broken on knife edges of $\frac{1}{4}$-inch radius set 5 inches apart. The shot was fed automatically at the rate of 12 pounds per minute. The modulus of rupture was calculated from data so obtained.

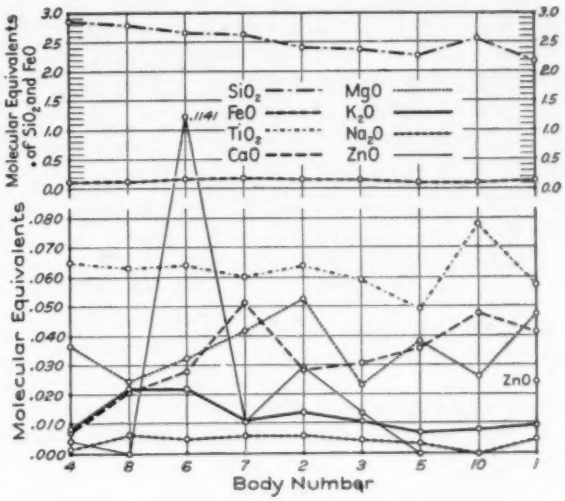

FIG. 7.—Chemical analyses of body mixtures.

(*b*) *Body Mixtures.*—The samples were taken from the pugged body mixture, brought to a soft plastic consistency with water, the test pieces formed to the same size and shape as the clay test pieces described above, and dried by the standard method. Fifteen test pieces were made from each sample, 5 each being fired respectively at 800°C, cones 4 and 12.

Slaking Test The test pieces were made of a mixture of 50% by weight of powdered flint and clay, the latter having been crushed to pass a 28-mesh sieve. The cubes were one inch in the plastic state. They were dried and slaked on a 3-mesh sieve; the temperature of the water was held at 25 ±1°C. The slaking time noted was the time required for the whole of the test piece to slake and settle through the screen.

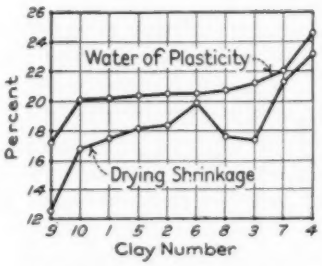

FIG. 8.—Water of plasticity and drying volume shrinkage of clays.

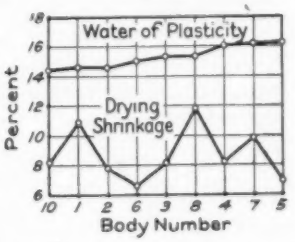

FIG. 9.—Water of plasticity and drying volume shrinkage of body mixtures.

Sag Test (*a*) *Clays.*—The samples were crushed to pass a 20-mesh screen, and mixed with water to form a slip. The test pieces were formed by pouring the slip into plaster molds, of such

size that after air drying, the test pieces could be cut to the proper breadth and thickness. The size of the finished test piece was ½ x 1 x 10 inches.

Two test pieces each were fired to cones 8, 10, 12, and 14 respectively. The span between knife edges was 7 inches. Gage marks were placed 7 inches apart, and the test pieces were set so that these marks would be directly over the supports before firing. After firing, the gage marks, due to shrinkage of the test piece, were between the knife edges. The deflection in inches (average of two results) was measured to the point of maximum deflection from a line joining the gage marks, the distance being measured normal to the line. It was found from the work on the clays that a modification in the size of the test pieces and the span length would probably be advantageous.

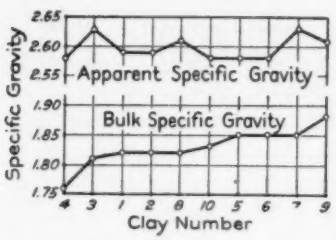

FIG. 10.—Apparent and bulk specific gravity of clays at 800°C.

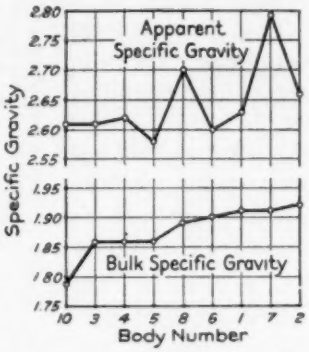

FIG. 11.—Apparent and bulk specific gravity of body mixtures at 800°C.

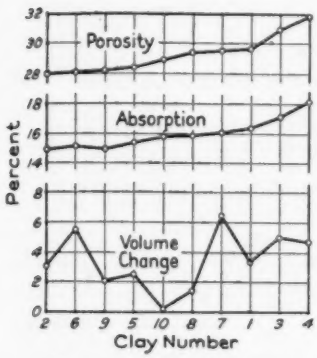

FIG. 12.—Porosity, absorption, and volume change of clays at 800°C.

(b) Body Mixtures.—Samples were taken from the pugged material, mixed with water to a plastic consistency, and formed in steel molds. The size of the plastic test pieces was 1 x 1 x 13 inches. After careful drying to prevent warping 2 test pieces from each body were fired to cones 10, 12, 14, and 16, respectively, the span between knife edges being 10 inches.

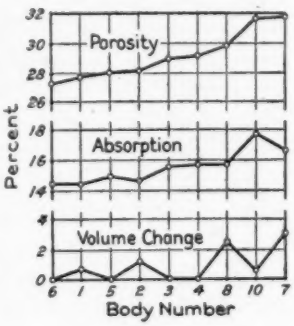

FIG. 13.—Porosity, absorption, and volume change of body mixtures at 800°C.

Spalling Test

The samples were taken from the pugged material, mixed with water to a soft, plastic consistency, and formed in steel molds. The size of the test pieces in the

plastic state was 1⅛ x 2½ x 6 inches. They were air dried in the usual manner and fired to 1400°C and held at that temperature for 5 hours.

In the spalling test, 4 pieces of each body mixture were fired to a temperature of 1270°C, care being taken to prevent the direct heating of more than the 1 x 2½-inch end. After one hour the specimens were withdrawn from the furnace door and plunged into a tank of flowing water (constant temperature 22°C), approximately one-half of the piece being immersed. After 3 minutes the sample was withdrawn from the water, allowed to steam 5 minutes, and then returned to the furnace. The alternate heating and cooling was continued for 20 hourly cycles. For each piece tested, the material that spalled off was collected after each dip, dried and weighed, the number of dips before the spalling commenced noted, and the final weight of the brick recorded.

TABLE I

CHEMICAL ANALYSES AND DEFORMATION VALUES OF CLAYS

Clay No.	1	2	3	4	5	6	7	8	9	10
SiO_2	46.49	47.66	44.11	52.21	44.35	53.40	44.51	47.52	55.52	59.67
Al_2O_3	32.52	31.40	33.34	28.37	33.29	27.77	33.05	31.41	28.37	24.49
Ignition loss	13.44	12.70	14.76	12.54	13.07	10.78	13.95	11.90	10.71	9.82
FeO	3.66	3.74	4.24	3.12	3.87	3.29	4.02	3.85	2.17	2.70
Fe_2O_3	4.07	4.15	4.71	3.46	4.30	3.65	4.47	4.28	2.41	3.00
TiO_2	1.78	1.54	1.58	1.60	1.49	1.31	1.47	1.42	1.41	1.41
MgO	0.71	0.72	0.66	0.58	0.75	0.59	0.54	0.59	0.41	0.33
CaO	0.79	0.77	0.52	0.15	0.97	0.70	0.69	1.08	0.77	0.67
Na_2O	0.20	0.21	0.13	0.00	0.18	0.06	0.17	0.03	0.09	0.05
K_2O	0.38	0.24	0.40	0.11	0.42	0.28	0.34	0.26	0.03	0.13
Deformation value (Orton cone)	29–30	29	29	28–29	28–29	28–29	29–30	27–28	30	29

NOTE—FeO in Tables I, III, and V calculated from value of Fe_2O_3.

TABLE II

MOLECULAR RATIOS IN CLAYS (Al_2O_3 Unity) (See Fig. 5)

Clay No.	SiO_2	FeO	TiO_2	MgO	CaO	Na_2O	K_2O
1	2.43	.159	.069	.056	.043	.01	.012
2	2.58	.169	.062	.058	.045	.011	.008
3	2.25	.180	.061	.052	.028	.006	.013
4	3.13	.155	.072	.054	.011	.00	.004
5	2.27	.166	.058	.058	.052	.009	.014
6	3.27	.169	.059	.055	.044	.004	.011
7	2.29	.173	.056	.043	.037	.008	.011
8	2.57	.172	.058	.049	.062	.002	.009
9	3.32	.108	.065	.036	.05	.005	.001
10	4.14	.158	.075	.033	.05	.003	.006

TABLE III

CHEMICAL ANALYSES AND DEFORMATION VALUES OF GROGS

Grog. No.	1	2	3	4	5	6	7	8	9	10
SiO_2	51.87	56.11	55.93	58.13	53.95	56.58	56.23	59.17	38.77	60.13
Al_2O_3	35.66	32.70	36.53	36.83	39.81	28.61	33.04	34.31	52.65	32.21
Ignition loss	0.45	1.76	0.67	0.63	0.72	0.89	0.73	0.16	0.19	0.11
FeO	4.53	3.55	2.57	2.38	0.98	2.69	4.65	1.71	1.97	3.02
Fe_2O_3	5.03	3.94	2.86	2.65	1.09	2.99	5.17	1.90	2.19	3.35
TiO_2	1.87	1.87	1.93	1.75	1.23	1.75	1.61	1.46	2.46	1.93
MgO	0.75	0.61	0.46	0.47	0.40	0.57	0.54	0.46	0.23	0.72
CaO	0.54	0.33	0.34	0.12	0.97	0.14	1.13	0.48	0.58	0.98
Na_2O	0.07	0.46	0.09	0.06	0.02	0.10	0.08	0.05	0.87	0.07
K_2O	0.33	0.69	0.50	0.39	0.07	1.19	0.41	0.74	0.89	0.33
Zinc	2.72	0.52	0.10	0.20	0.0	4.59	0.51	0.0	0.0	0.0
Deformation value (Orton cone)	27	28–29	31	30–31	32–33	20–23	26–27	30–31	35	28–29

TABLE IV

MOLECULAR RATIOS IN GROGS (Al_2O_3 Unity) (See Fig. 6)

Grog. No.	SiO_2	FeO	TiO_2	MgO	CaO	Na_2O	K_2O	ZnO
1	2.48	0.181	0.066	0.054	0.029	0.003	0.010	0.098
2	2.91	0.153	0.072	0.047	0.019	0.023	0.023	0.019
3	2.60	0.101	0.067	0.034	0.017	0.004	0.015	0.003
4	2.68	0.091	0.061	0.033	0.006	0.003	0.011	0.005
5	2.31	0.036	0.038	0.026	0.044	0.008	0.002	—
6	3.37	0.132	0.079	0.050	0.007	0.006	0.045	0.204
7	2.89	0.200	0.062	0.043	0.062	0.004	0.013	0.019
8	2.93	0.071	0.054	0.036	0.024	0.002	0.024	—
9	1.25	0.052	0.060	0.012	0.019	0.027	0.018	—
10	3.20	0.133	0.076	0.057	0.054	0.003	0.011	—

TABLE V

CHEMICAL ANALYSES OF BODY MIXTURES

Body No.	1	2	3	4	5	6	7	8	10
SiO_2	47.08	49.34	49.06	55.50	48.42	51.18	50.96	53.92	48.00
Al_2O_3	36.42	34.76	34.83	33.07	36.09	32.66	33.05	33.20	31.87
Ignition loss	6.62	6.94	7.75	6.25	7.21	5.54	7.00	5.82	11.96
FeO	4.03	4.26	4.07	2.70	2.89	3.74	4.37	2.66	2.54
Fe_2O_3	4.48	4.73	4.52	3.00	3.21	4.16	4.86	2.96	2.82
TiO_2	1.64	1.74	1.62	1.68	1.40	1.66	1.56	1.64	1.95
MgO	0.68	0.72	0.32	0.47	0.54	0.41	0.54	0.32	0.33
CaO	0.83	0.54	0.59	0.13	0.71	0.50	0.93	0.38	0.84
Na_2O	0.11	0.13	0.10	0.033	0.08	0.10	0.12	0.13	0.00
K_2O	0.32	0.45	0.35	0.265	0.24	0.66	0.38	0.67	0.24
ZnO	0.71	0.81	0.38	0.11	0.00	2.96	0.28	0.00	(Carbon 7.17)
Deformation value (Orton cone)	27–28	27–28	30	28–29	30–31	26	27	28–29	30–31

TABLE VI

MOLECULAR RATIOS IN BODY MIXTURES (Al_2O_3 Unity) (See Fig. 7)

Body No.	SiO_2	FeO	TiO_2	CaO	MgO	Na_2O	K_2O	ZnO
1	2.199	0.1569	.0574	.0415	.0476	.0050	.0095	0.0245
2	2.413	0.1735	.0638	.0283	.0528	.0061	.0140	.0293
3	2.394	0.1655	.0593	.0309	.0234	.0047	.0109	.0137
4	2.850	0.1157	.0648	.0072	.0364	.0015	.0085	.0042
5	2.281	0.1134	.0495	.0358	.0382	.0036	.0072	.0000
6	2.664	0.1624	.0648	.0279	.0322	.0050	.0219	.1141
7	2.621	0.1874	.0602	.0513	.0417	.0060	.0125	.0107
8	2.761	0.1137	.0629	.0208	.0246	.0064	.0219	.0000
10	2.560	0.1128	.0780	.048	.0264	.0000	.0082	—

TABLE VII
SCREEN ANALYSES OF GROGS

		Grog No. 1		Grog No. 2		Grog No. 3		Grog No. 4		Grog No. 5	
	On mesh no.	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %
	6	0.21	0.21	6.53	6.53	0.2	0.20	0.46	0.46	0.25	0.25
	8	13.72	13.93	14.07	20.60	14.3	14.50	8.35	8.81	12.18	12.43
	10	21.03	34.96	16.00	36.60	19.88	34.38	15.08	23.88	23.31	35.74
	14	13.48	48.44	10.64	47.24	13.23	47.61	12.13	36.01	16.10	51.83
	20	11.96	60.40	10.02	57.26	11.92	59.53	12.08	48.09	13.52	65.36
	28	9.62	70.02	8.65	65.91	9.61	69.14	10.77	58.85	10.07	75.43
	35	8.77	78.79	8.16	74.07	8.40	77.53	10.06	68.92	7.79	83.21
	48	5.59	84.38	5.46	79.53	5.44	82.97	6.82	75.74	4.52	87.74
	65	4.24	88.62	4.66	84.19	4.39	87.36	5.63	81.37	3.24	90.97
	100	3.25	91.87	3.89	88.08	3.51	90.86	4.86	86.23	2.62	93.60
	150	2.27	94.14	3.14	91.22	2.59	93.46	3.75	89.98	1.92	95.51
	200	1.32	95.46	2.12	93.34	1.64	95.10	2.46	92.44	1.16	96.68
Through	200	4.44	99.90	6.65	99.99	4.9	99.99	7.56	99.99	3.32	99.99

		Grog No. 6		Grog No. 7		Grog No. 8		Grog No. 9		Grog No. 10	
	On mesh no.	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %	Per cent	Cumulative %
	6	1.30	1.30	0.14	0.14	2.36	2.36	0.54	0.54	0.39	0.39
	8	8.42	9.72	8.28	8.42	13.13	15.49	19.25	19.79	13.67	14.06
	10	22.67	32.39	38.70	47.12	24.08	39.57	23.33	43.12	17.73	31.79
	14	14.25	46.64	20.66	67.78	15.28	54.85	13.68	56.80	11.12	42.91
	20	12.22	58.86	12.43	80.21	12.09	66.94	11.82	68.62	9.93	52.84
	28	9.54	68.40	6.32	86.53	9.11	76.06	9.21	77.83	8.48	61.32
	35	8.38	76.78	3.79	90.31	7.38	83.44	7.35	85.18	8.21	69.53
	48	5.41	82.19	1.91	92.22	4.54	87.98	4.52	89.70	5.81	75.33
	65	4.30	86.49	1.38	93.60	3.33	91.31	3.11	92.81	5.04	80.37
	100	3.34	89.83	1.17	94.77	2.57	93.87	2.60	95.41	4.59	84.96
	150	2.50	92.33	1.04	95.81	1.87	95.74	1.71	97.11	4.14	89.10
	200	1.62	93.95	0.78	96.59	1.08	96.81	0.89	98.01	3.06	92.16
Through	200	6.05	100.00	3 41	100.00	3.19	100.00	1.99	99.99	7.83	99.99

TABLE VIII

WATER OF PLASTICITY AND DRYING VOLUME SHRINKAGE

	Number	1	2	3	4	5	6	7	8	9	10
Clays	Per cent water of plasticity	20.2	20.5	21.2	24.5	20.4	20.5	22.0	20.7	17.2	20.1
	Per cent drying shrinkage	17.5	18.4	17.4	23.1	18.2	19.9	21.3	17.6	12.6	16.8
Body mixture	Per cent water of plasticity	14.6	14.6	15.3	16.0	16.2	15.0	16.1	15.3		14.4
	Per cent drying shrinkage	10.9	7.8	8.1	8.2	6.9	6.6	9.8	11.8		8.2

TABLE IX

APPARENT AND BULK SPECIFIC GRAVITY ON CLAYS AND BODY MIXTURES FIRED AT 800°C

	Number	1	2	3	4	5	6	7	8	9	10
Clays	Apparent specific gravity	2.59	2.59	2.63	2.58	2.58	2.58	2.63	2.61	2.61	2.58
	Bulk specific gravity	1.82	1.82	1.81	1.76	1.85	1.85	1.85	1.82	1.88	1.83
Body Mixtures	Apparent specific gravity	2.63	2.66	2.61	2.62	2.58	2.60	2.79	2.70		2.61
	Bulk specific gravity	1.91	1.92	1.86	1.86	1.86	1.90	1.91	1.89		1.79

TABLE X

POROSITY, ABSORPTION AND VOLUME CHANGE OF CLAYS AND BODY MIXTURES FIRED AT 800°C

	Number	1	2	3	4	5	6	7	8	9	10
Clays	Per cent porosity	29.6	27.95	30.85	31.75	28.4	28.1	29.5	29.35	28.15	28.9
	Per cent absorption	16.3	14.95	17.05	18.1	15.35	15.2	16.0	15.9	15.0	15.8
	Per cent volume change	3.3	3.1	4.9	4.6	2.5	5.45	6.4	1.35	2.05	0.15
Body mixtures	Per cent porosity	27.65	28.05	28.85	29.1	27.95	27.3	31.7	29.75		31.55
	Per cent absorption	14.45	14.7	15.55	15.7	15.0	14.45	16.6	15.7		17.65
	Per cent volume change	0.7	1.2	0.0	0.0	0.0	0.0	2.99	2.42		0.45

TABLE XI

POROSITY, ABSORPTION, AND VOLUME CHANGE OF CLAYS

Number	Porosity at cones					Absorption at cones					Volume change at cones				
	6	8	12	14	16	6	8	12	14	16	6	8	12	14	16
1	21.0	21.2	15.65	12.3	11.0	9.88	10.03	6.06	5.75	5.11	18.55	17.85	14.95	18.9	19.4
2	18.4	18.35	11.55	7.24	8.64	8.36	8.47	5.30	3.11	3.95	19.1	18.0	18.75	22.7	18.9
3	20.75	21.7.	14.65	9.75	11.65	9.68	10.4	7.06	4.56	5.46	20.65	20.4	18.1	20.85	21.4
4	20.75	20.3	14.35	7.73	8.23	9.83	9.63	6.74	3.37	3.73	19.55	20.4	21.45	27.15	23.5
5	17.0	17.2	13.95	11.15	10.36	7.68	7.97	6.71	5.30	5.04	20.65	18.95	16.25	18.1	13.95
6	23.05	21.6	18.7	13.75	11.35	10.95	10.35	8.88	6.30	5.21	15.75	14.75	14.85	18.55	18.35
7	18.0	17.9	12.9	7.23	7.65	8.19	9.18	5.81	3.16	3.4	21.55	22.15	22.55	22.95	23.75
8	22.25	21.75	18.1	11.6	9.17	10.5	10.3	8.52	5.22	4.24	16.55	16.1	17.3	20.4	18.75
9	22.05	21.8	20.3	17.5	14.5	10.65	10.70	9.72	8.28	6.75	11.45	8.89	12.05	12.65	14.9
10	26.45	25.85	23.1	21.85	18.6	13.15	13.15	11.77	10.65	8.83	9.65	8.46	7.68	11.45	13.95

TABLE XII

POROSITY, ABSORPTION, AND VOLUME CHANGE OF BODY MIXTURES

Number	Porosity at cones					Absorption at cones					Volume change at cones				
	6	8	12	14	16	6	8	12	14	16	6	8	12	14	16
1	26.4	25.63	23.5	21.54	16.95	13.3	12.6	11.62	10.40	8.27	4.06	6.30	7.18	8.63	6.04
2	25.45	25.05	21.8	18.6	15.9	12.9	12.7	10.93	9.31	7.84	4.79	6.37	6.65	7.68	6.37
3	27.4	25.8	24.05	22.2	20.05	14.0	13.4	12.16	11.52	10.24	5.55	5.61	7.03	7.85	5.88
4	28.75	27.45	25.65	23.3	22.3	14.7	14.2	12.98	11.87	11.43	5.73	4.46	5.86	6.25	6.7
5	22.95	21.8	18.55	16.8	16.4	10.8	10.3	8.71	7.73	7.46	13.35	13.34	12.65	14.5	17.45
6	24.95	23.75	20.75	17.8	14.4	12.3	11.45	9.88	8.77	7.30	6.53	8.59	8.03	6.20	1.57
7	28.5	26.85	24.8	19.5	17.7	14.6	13.75	12.21	9.58	8.59	4.74	6.19	9.10	9.02	10.8
8	28.0	28.9	27.1	24.0	19.6	14.75	15.3	14.15	12.35	9.74	3.45	4.89	4.27	6.13	10.4
10	32.3	33.0	31.7	29.8	29.0	17.6	17.7	16.50	15.65	14.69	6.58	6.49	8.27	9.15	11.6

TABLE XIII

APPARENT AND BULK SPECIFIC GRAVITY OF CLAYS

Number	Per cent apparent specific gravity at cones					Per cent bulk specific gravity at cones				
	6	8	12	14	16	6	8	12	14	16
1	2.70	2.68	2.46	2.44	2.42	2.13	2.12	2.08	2.15	2.16
2	2.70	2.66	2.47	2.51	2.61	2.20	2.17	2.18	2.33	2.20
3	2.70	2.67	2.44	2.37	2.41	2.14	2.10	2.08	2.14	2.13
4	2.67	2.65	2.49	2.49	2.41	2.11	2.11	2.14	2.30	2.21
5	2.67	2.61	2.42	2.37	2.29	2.21	2.16	2.08	2.11	2.09
6	2.76	2.66	2.60	2.53	2.47	2.12	2.09	2.11	2.18	2.19
7	2.68	2.67	2.55	2.47	2.44	2.19	2.19	2.22	2.30	2.26
8	2.73	2.69	2.59	2.51	2.39	2.12	2.11	2.13	2.23	2.17
9	2.64	2.59	2.62	2.57	2.52	2.06	2.03	2.09	2.12	2.15
10	2.73	2.66	2.55	2.62	2.59	2.01	1.97	1.96	2.05	2.11

TABLE XIV

APPARENT AND BULK SPECIFIC GRAVITY OF BODY MIXTURES

Number	Per cent apparent specific gravity at cones					Per cent bulk specific gravity at cones				
	6	8	12	14	16	6	8	12	14	16
1	2.70	2.73	2.64	2.64	2.47	1.99	2.03	2.08	2.03	2.05
2	2.65	2.64	2.55	2.46	2.41	1.98	1.98	2.00	2.00	2.03
3	2.70	2.62	2.61	2.59	2.45	1.96	1.94	1.98	2.02	1.96
4	2.76	2.66	2.66	2.56	2.55	1.97	1.94	1.98	1.96	1.98
5	2.75	2.70	2.62	2.62	2.63	2.12	2.11	2.13	2.17	2.20
6	2.70	2.73	2.65	2.48	2.30	2.03	2.08	2.10	2.04	1.97
7	2.75	2.66	2.60	2.53	2.51	1.95	1.95	2.04	2.04	2.06
8	2.64	2.66	2.62	2.56	2.50	1.90	1.89	1.91	1.95	2.01
10	2.71	2.80	2.81	2.71	2.77	1.84	1.87	1.93	1.91	1.97

TABLE XV

MODULUS OF RUPTURE (SAND MIX) AND SLAKING OF CLAYS

Number		1	2	3	4	5	6	7	8	9	10
Modulus of Rupture (lbs. per sq. in.)		158	166	160	163	156	194	155	183	179	165
Slaking time	Min.	43	12	13	19	12	17	11	9	29	14
	Sec.	53	10	48	34	4	25.5	0	53	9	0

TABLE XVI

MODULUS OF RUPTURE OF BODY MIXTURES AT 800°C, 1100°C, AND 1300°C

Number		1	2	3	4	5	6	7	8	10
Modulus of Rupture	800°C	512	492	277	292	452	307	400	482	338
	1100°C	951	791	502	545	734	559	831	1156	1066
	*1300°C	1424	1249	858	1059	1183	923	1410	1729	1358

* Note: The firing was to temperatures of 800°C, cones 4 and 12. At the time of firing however, temperature was recorded with a platinum-platinum-rhodium couple. It was found that 1100°C and 1300°C respectively, corresponded to the deformation values of cones 4 and 12.

TABLE XVII

SAG TEST OF CLAYS AT CONES 8, 10, 12, AND 14

Number		1	2	3	4	5	6	7	8	9	10
Deflection in in. for a length of 7 in. at	Cone 8	0.11	0.09	0.145	0.080	0.105	0.080	0.135	0.130	0.165	0.115
	Cone 10	0.140	0.105	0.170	0.130	0.145	0.120	0.090	0.155	0.125	0.120
	Cone 12	0.185	0.180	0.210	0.195	0.130	0.135	0.170	0.170	0.205	0.135
	Cone 14	0.520	0.430	0.695	0.360	0.585	0.285	0.485	0.420	0.355	0.270

TABLE XVIII

SAG TEST OF BODY MIXTURES AT CONES 10, 12, 14, AND 16

Number		1	2	3	4	5	6	7	8	10
Deflection in in. for a length of 10 in. at	Cone 10	0.130	0.140	0.180	0.165	0.190	0.240	0.180	0.130	0.200
	Cone 12	0.175	0.220	0.230	0.230	0.205	0.350	0.255	0.175	0.190
	Cone 14	0.350	0.390	0.520	0.405	0.410	0.755	0.480	0.275	0.310
	Cone 16	0.820	0.720	0.985	0.810	0.480	1.170	1.005	0.465	0.460

TABLE XIX

SPALLING TEST OF BODY MIXTURES

Number		1	2	3	4	5	6	7	8	10
Number of dips before spalling started		14.25	8.75	18.00	17.50	16.25	4.75	8.50	10.25	17.00
Av. per cent loss wt.	Spalling and cracking	17.66	30.46	0.95	4.18	2.54	47.44	34.22	25.84	13.47
	Spalling	0.88	23.38	0.95	4.18	2.54	27.34	21.48	8.32	13.47

TABLE XX

DEFLECTION, FREE AND TOTAL SiO_2, AND FLUX VALUES OF CLAYS

Number		1	2	3	4	5	6	7	8	9	10
*Deflection in inches		0.520	0.430	0.695	0.360	0.585	0.285	0.485	0.420	0.355	0.270
Molecular Equivalent	Free SiO_2	0.430	0.580	0.250	1.130	0.270	1.270	0.290	0.570	1.320	2.140
	Total SiO_2	2.430	2.580	2.250	3.130	2.270	3.270	2.290	2.570	3.320	4.140
	Flux	0.349	0.353	0.340	0.296	0.357	0.342	0.328	0.352	0.265	0.325

* Deflection values at cone 14.

TABLE XXI

TOTAL SiO_2 AND FLUX VALUES (MOLECULAR EQUIVALENTS) OF GROGS

Number	1	2	3	4	5	6	7	8	9	10
Total SiO_2	2.48	2.91	2.60	2.68	2.31	3.37	2.89	2.93	1.25	3.20
Flux	0.441	0.356	0.241	0.210	0.154	0.523	0.403	0.211	0.188	0.334

TABLE XXII

DEFLECTION, VOLUME CHANGE, AND FLUX VALUES OF BODY MIXTURES

Number	1	2	3	4	5	6	7	8	10
*Deflection in inches	0.820	0.720	0.985	0.810	0.480	1.170	1.005	0.465	0.460
Volume change	6.04	6.37	5.88	6.70	17.45	1.57	10.80	10.40	11.60
Flux	0.342	0.368	0.308	0.238	0.248	0.428	0.370	0.250	0.273

* Deflection value at cone 16.

Zinc Content of Old Retorts, and Effect of Zinc on the Deformation Value of Clays

Several samples of old retorts showing varying amounts of zinc penetration were secured. These were analyzed, the results being shown in Table XXIII.

To determine the effect of zinc upon the deformation value of clay two samples of clay were chosen, having average deformation values. A series of cones were made from both clays in which a varying amount of zinc oxide was added to give the following calculated zinc content.

Series No. 1	4.00 % zinc
" " 2	8.00 " "
" " 3	12.00 " "

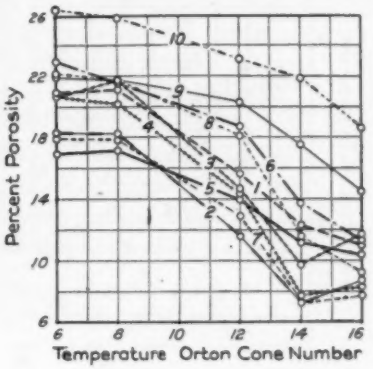

FIG. 14.—Porosity of clays at cones 6, 8, 12, 14, and 16.

These cones, prior to the deformation value determination, were given a preliminary heating. The top of each cone was taken for deformation value determination while the lower portion was crushed for chemical analysis. As a number of "check" determinations were made, a fair sample for chemical analysis was obtained. Samples of two deformed cones were analyzed to ascertain if appreciable zinc loss occurred during the deformation value determination.

TABLE XXIII

ANALYSES OF OLD RETORTS AND SLAG

Description	Sample No. 1 Old retort showing average penetration	Sample No. 2 Old retort showing extensive penetration	Sample No. 3 Used retort showing average penetration	Sample No. 3A Old retort showing extensive penetration	Sample No. 4 Old retort showing extensive penetration	Sample No. 5 Old retort showing extensive penetration	Sample No. 6 Old retort showing average penetration	Sample No. 7 Slag from old retorts
Zinc	3.29	5.14	5.85	15.40	11.30	5.24	4.21	5.24
SiO_2	57.76	55.36	*51.50	48.60	46.84	53.04	53.42	55.02
Al_2O_3	30.68	30.29	35.70	26.21	31.61	31.96	32.23	15.15
Fe_2O_3	3.98	4.21	3.88	3.88	5.14	5.48	5.73	10.19
TiO_2	1.76	1.52	1.64	1.23	1.17	1.76	1.76	0.82
CaO	1.25	1.16	1.23	1.04	1.23	1.25	1.13	4.67
MgO	0.43	0.54	Trace	0.46	0.28	0.20	0.45	1.42
Totals**	99.96	99.48	101.23	100.59	100.34	100.21	99.96	*94.79
Deformation value (Orton cone)	17–18	17	20–23	12	12	15–16	15–16	Lower than 02

* Carbon content not determined
** Zinc computed to ZnO in totals

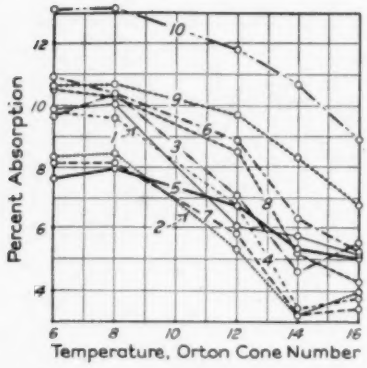

FIG. 15.—Absorption of clays at cones 6, 8, 12, 14, and 16.

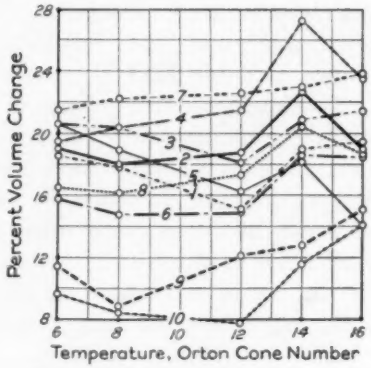

FIG. 16.—Volume change of clays at cones 6, 8, 12, 14, and 16.

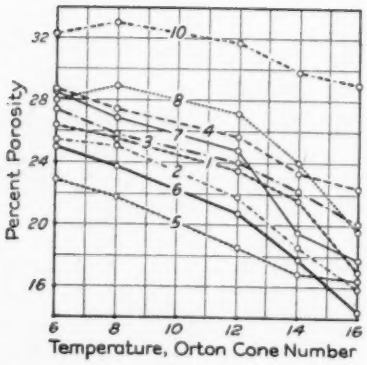

FIG. 17.—Porosity of body mixtures at cones 6, 8, 12, and 16.

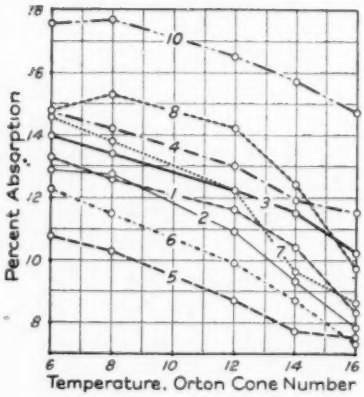

FIG. 18.—Absorption of body mixtures at cones 6, 8, 12, 14, and 16.

TABLE XXIV

EFFECT OF ZINC UPON THE DEFORMATION VALUE OF FIRE CLAY

Number		5	5	5	8	8	8
Per cent zinc content	Calculated	4.00	8.00	12.00	4.00	8.00	12.00
	Analysis	4.86	8.07	10.96*	4.55	7.34	9.82*
Deformation value at cone number	Clay	28–29	28–29	28–29	27–28	27–28	27–28
	Clay with ZnO added	23–26	18–19	16–17	19–20	18–19	15–16

* After deforming these samples contained 10.47% and 9.56% zinc, respectively, showing that loss during the deformation value determination was negligible.

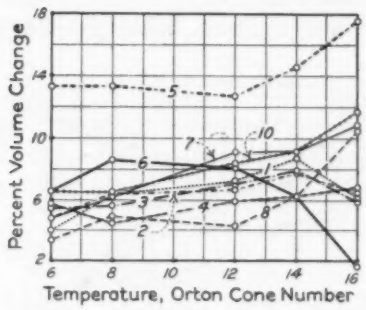

FIG. 19.—Volume change of body mixtures at cones 6, 8, 12, 14 and 16.

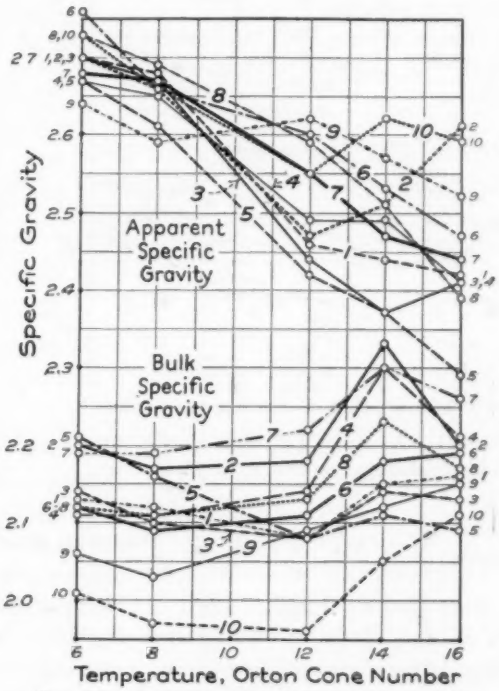

FIG. 20.—Apparent and bulk specific gravity of clays at cones 6, 8, 12, 14, and 16.

Discussion of Results

In summarizing the results of the tests that were made, they are taken up under three headings: clays, grogs, and body mixtures.

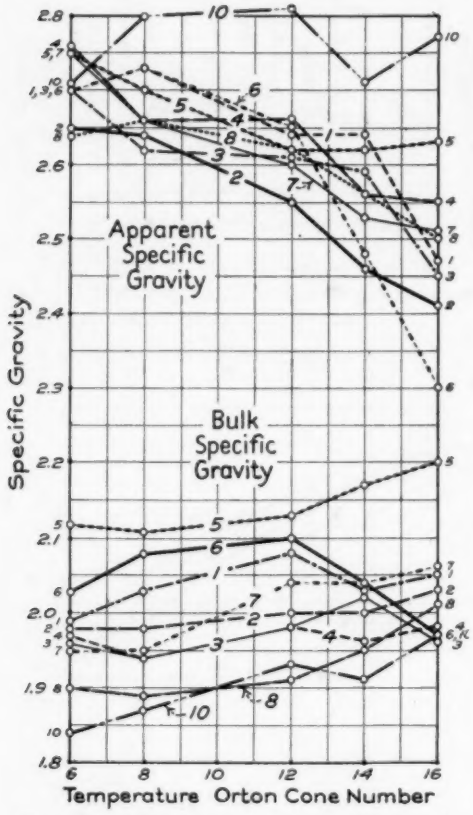

FIG. 21.—Apparent and bulk specific gravity of body mixtures at cones 6, 8, 12, 14, and 16.

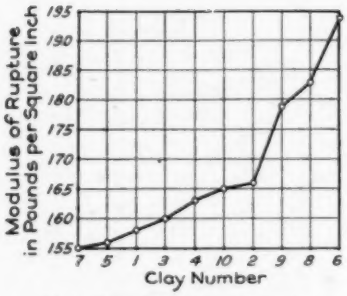

FIG. 22.—Modulus of rupture (sand mix) of clays.

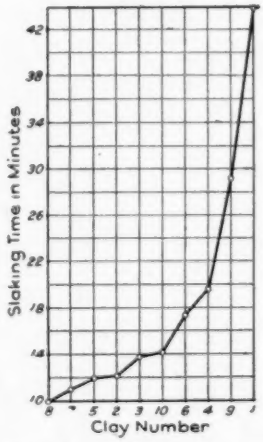

FIG. 23.—Slaking of clays.

Clays The clays used at all the zinc smelters from which samples were obtained are plastic fire clays from mines located in or around St. Louis. There is little variation in the physical properties of the clays, probably due to their similar flux content. The deformation temperature of the bond clays seems to have no relation to the chemical composition (Fig. 5). All the clays tested lay between cones 27½ and 30 (Fig. 5). An average content of 20% water was required to form a soft plastic mixture (Fig. 8). The drying shrinkage averaged 18.5% (Fig. 8).

The behavior of the clays in firing to 800°C (usual tempering temperature) was fairly uniform, the volume change ranging from almost nothing to slightly over 6%, porosity from 28 to 32%, and absorption from 15 to 18% (Fig. 12).

The modulus of rupture varied, for the green clays, from 155 to 194 pounds per square inch (Fig. 22). The slaking time varied from 10 to 44 minutes (Fig. 23).

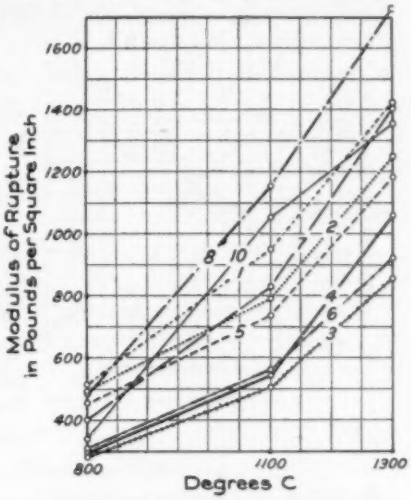

FIG. 24.—Modulus of rupture of body mixtures at 800°C, 1100°C, and 1300°C.

The sagging of the clay test pieces was low, differences not being marked up to and including cone 12. Larger deflections and variations were observed at cone 14, however, the former ranging from 0.27 to 0.695 inch (Fig. 25). There is an apparent relation between the free silica content and the deflection, while no relation seems evident between the flux content and the deflection (Fig. 28). There seems to be a direct relationship between deformation value and zinc content (Fig. 33).

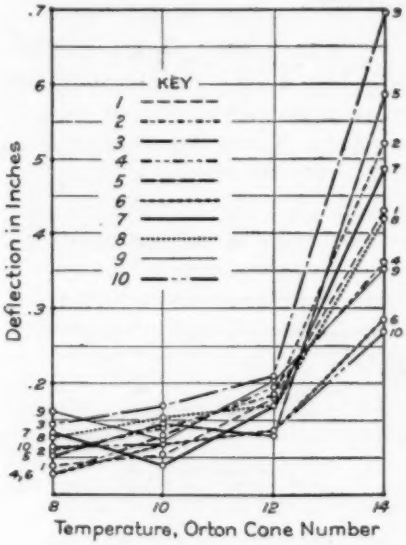

FIG. 25.—Sag test of clays fired at cones 8, 10, 12, and 14.

Grogs The deformation values of the various grogs ranged from cones 21½ to 35½ (Fig. 6). There is a distinct relationship evident

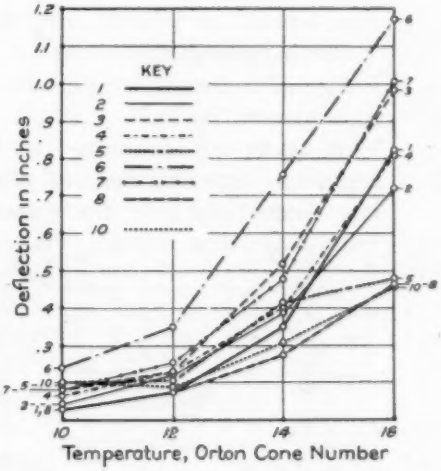

FIG. 26.—Sag test of body mixtures fired at cones 10, 12, 14, and 16.

between the deformation values of the grogs when the flux content is plotted against the total silica content (Fig. 30). In plotting the deformation values with chemical composition a distinct relationship is seen to exist between the Al_2O_3 content and the deformation values (Fig. 6). The uniformity in the size of the grog used at different plants is remarkable; only one sample, No. 7, being markedly different from the average (Fig. 7).

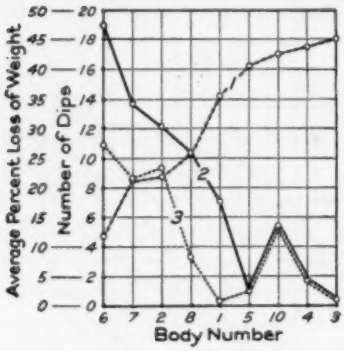

FIG. 27.—Spalling test of body mixtures.

Body Mixtures An average content of 15% water was required to form a soft plastic mixture (Fig. 9). The drying shrinkage of the body mixes averaged 8.7% and showed no relation to the drying shrinkage of the bond clays used in them (Figs. 8 and 9). The volume change or shrinkage in firing to 800°C was less than 3% (Fig. 13); the porosity averaged 29% (Fig. 13). Body mixture No. 5 showed an especially high shrinkage at higher temperatures (Fig. 19). The high porosity of body mixture No. 10 was due, no doubt, to the firing out of the coke contained in it.

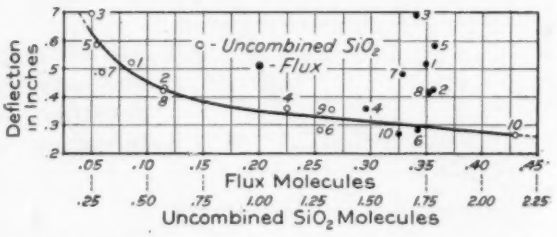

FIG. 28.—Deflection of free SiO_2, and flux values of clays.

The sagging of the body mixture test pieces was fairly uniform up to and including cone 12. At cones 14 and 16, however, the deflection increased markedly, ranging from 0.46 to 1.17 inches at the latter cone (Fig. 26). There seems to be a direct relation between deflection and flux content (Fig. 32) and an inverse relation between volume change and deflection (Fig. 31). The resistance of the body mixtures to spalling varied considerably (Fig. 27).

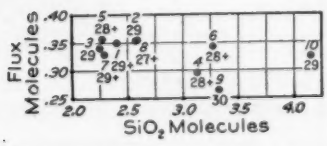

FIG. 29.—Flux and total SiO_2 values of clays.

Summary

The object of this part of the investigation was a study of the properties of the raw materials now used for the manufacture of retorts in the metallurgy of zinc; this study to assist

further research, in which the properties of various clays and grogs are to be determined. No attempt is made to offer any of the results secured in this investigation as conclusions as to the relative value of the various body mixtures studied. It is thought, however, that the following points, none of which are new but which this research tends to confirm, warrant presentation:

1. Only minor differences were observed among the properties of the clays.
2. The use of reclaimed retort material in the grog for new retorts is of doubtful economy.
3. If old bricks or shapes are used as grog, care should be taken that they were originally made of good quality clay and that they are free from slags.
4. Some flint clay of good quality and properly calcined is advisable for at least a part of the grog.
5. Zinc in a clay or body mixture markedly affects the refractoriness by lowering the deformation value.

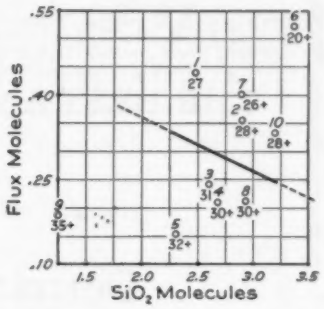

FIG. 30.—Total SiO_2 and flux values of grogs.

Intelligent selection of the raw materials, from which a body mixture is to be prepared, can only be made after consideration of the properties of the available clays and grogs. In choosing a bond clay some refractoriness must be sacrificed to secure the requisite plasticity, binding power, and low shrinkage. The St. Louis plastic fire clays combine these latter qualities with fairly high refractoriness. The grog, in turn, which is always calcined, and therefore possesses no plasticity, should be chosen for its refractory qualities. If flint clays, after calcination, are used for grog, they add to the refractoriness of the body mixture, whereas if reclaimed old retort material is used as grog the body may be less refractory than the bond clay itself.

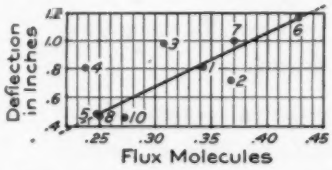

FIG. 31.—Deflection and flux values of body mixtures.

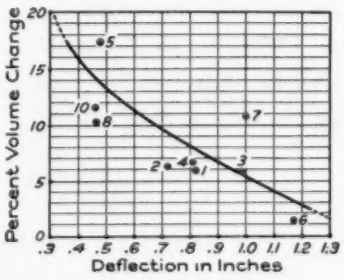

FIG. 32.—Deflection and volume change values of body mixtures.

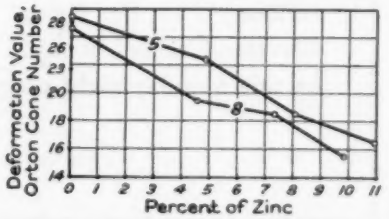

FIG. 33.—Effect of zinc upon the deformation values of fire clay.

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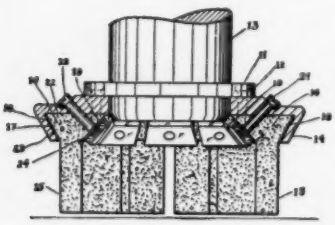
Abrasives

An improved abrasive grain. ANON. *Fuels and Fur.*, **4** [12], 1508(1926).—An announcement of a new process which eliminates weak, flat, slivery grains resulting in more uniform size, strength, and shape. The advantages are pointed out.

A.E.R.W.

PATENT



Mounting for segmental wheels. THURE LARSSON. U.S. 1,611,352, Dec. 21, 1926. An abrasive wheel comprising a rotatable driving head having an annular flange, a plurality of abrasive segments having enlarged heads thereon, and clamping blocks adjustably mounted on the head and arranged to wedge the segments against the flange and head and removably fasten them rigidly in position.

Art

The color of the ruby. CHAS. W. STILLWELL. *Jour. Phys. Chem.*, **30** [11], 1441–66(1926).—Alpha alumina colored by red Cr_2O_3 becomes bluish-red when fused in a reducing atmosphere due to formation of some blue CrO. The conditions necessary to complete the reduction and give a sapphire blue corundum are yet to be determined. The blue crystals observed in the artificial rubies are believed to be colored by CrO for two reasons: (1) CrO is exactly this shade of blue, at least when dissolved in beryllium aluminum silicate, and (2) there is no other impurity present in the mixture used which would produce that shade of blue. The cause of the blue color of the natural sapphire is not known. It is very probable that the color of all sapphires is not caused by the same impurity.

L.A.P.

The story of the willow-pattern plate. BROWNING. *Pottery Gaz.*, **51** [593], 1732–35(1926).—The legend embodied in the decoration of the common willow-pattern plate, so named because the figure of a willow tree occupies the center of the plate, is

given in full. This history is to the Chinese what our "Jack the Giant Killer," or "Robinson Crusoe" are to us. E.J.V.

Designing for industry: the advantages and disadvantages of the machine. S. B. WAINWRIGHT. *Commercial Art*, **1**, 36–38 (1926).—Design comes into the industrial field in the actual form of the product, and in that sense is an acute question at every stage of the mechanical process of production. Design is also the application of attractive details without any organic relation to the product. In the first case, design is efficiency, in the second, appeal. Artists should frankly accept the machine, which gives perfect geometrical accuracy and multiplicity. H.H.S.

Poole pottery. ANON. *Commercial Art*, **1**, 83–85 (1926).—An illustrated account of the ware produced by Carter, Stabler, & Adams, Ltd. H.H.S.

The Wiener Werkstätte and Austrian industry. A. S. LEVETUS. *Commercial Art*, **1**, 137–40 (1926).—The Vienna "Secession" of artists in 1897 initiated the modern movement of exhibitions at home and in foreign countries, and resulted in the foundation of the Werkstätte which supplies designs for manufacturers of glassware, pottery, electric fittings, iron goods, silks, and many other industrial articles. The world prestige of Viennese goods is held to be due to this institution, designs of which are illustrated. H.H.S.

German industry: training the designers. W. LOTZ. *Commercial Art*, **1**, 156–59 (1926). H.H.S.

Modern shop fronts. S. B. WAINWRIGHT. *Commercial Art*, **1**, 235–38 (1926). H.H.S.

Applied art in Great Britain. C. TENNYSON. *Commercial Art*, **1**, 18–22 (1926). H.H.S.

Lalique's glassware. G. MOUREY. *Commercial Art*, **1**, 31–36 (1926). H.H.S.

Cement, Lime, and Plaster

A preliminary petrographic study of Portland cement. JOSEPH L. GILLSON AND ELMER C. WARREN. *Jour. Amer. Ceram. Soc.*, **9** [12], 783–86 (1926).—A microscopic study was made of the clinker of 5 commercial brands of cement. Three crystalline compounds make up over 95% of these clinkers. The optical properties of 2 of these were determined; one, the principal constituent, is uniaxial and negative and has indices of 1.726 and 1.730. The other is biaxial and positive and has indices of 1.718, 1.720, and 1.733. This compound was found in both the clinker and the set concrete, proving that it is an inert substance without hydraulic properties. The optical properties of these compounds are not the same as those of any of the members of the CaO-Al_2O_3-SiO_2 system determined by Rankin and Wright.

Portland-blast-furnace cement: Standard British specifications. ANON. *Engineering*, **122**, 383 (1926).—In No. 146 (1926) of the B.E.S.A. provision is made for testing in hot countries up to 95°F. In climates where the temperature may be above 95°F or below 58°F, special arrangements have to be made between vendor and purchaser unless the specification range can be artificially produced. The cement is now required to be more finely ground. The maximum hydraulic modulus of Portland cement clinker has been raised to 2.90 and the maximum MgO is now 4%. The minimum tensile breaking strength of neat cement (7 days) has been increased to 600 lbs. per sq. in. and that of cement and sand to 325 lbs. per sq. in. The 28-day test on neat cement has been eliminated. The initial setting time of normal setting cement is to be not less than 30 minutes, and of quick setting cement not less than 5 minutes. H.H.S.

Calimite electric furnace. ANON. *Chem. Eng. Min. Rev.*, **19**, 16 (1926).—The calimite furnace has been developed for burning limestone and gypsum, and for roasting

arsenical pyrites and other ores, where the heat required varies from anything up to 1100°C. The furnace is of the rotary type; the special advantages claimed for it are: (*a*) the heat control is perfect; (*b*) the products of combustion do not come in contact with the material during roasting; (*c*) fines can be efficiently treated; (*d*) the carbon dioxide produced from limestone is pure and can be saved; (*e*) no space is required for stacking or storing fuel; (*f*) 95% of the heat is utilized, as against 30% in ordinary lime-burning operations; (*g*) it can be applied to the distillation of oil-shales.

O.P.R.O.

Enamels

The theory of pickling of sheet iron and steel for enameling purposes. HOMER F. STALEY. *Jour. Amer. Ceram. Soc.*, **9** [12], 787–96 (1926).—The fundamental principal of efficient pickling is that efficient pickling does not depend on the solution of a large amount of metal but on the solution of a very thin layer of metal directly beneath the scale, rapidly and with copious evolution of hydrogen. The activity of an acid solution depends on the amount of acid present, the fraction of the acid that is ionized, and on the speed with which the ions move. Since the electrical conductivity of an acid solution is a measure of both the hydrogen-ion concentration and the speed at which the ions move, the electrical conductivities of a series of acid solutions indicate the relative activities of the various solutions. The most effective concentrations of acid lie between 15 and 20%. Heating acid solutions reduces their viscosity and renders the particles more mobile, thus increasing the activity of the solutions. Sulphuric acid is cheaper in first coat than hydrochloric acid, but the latter acts more rapidly and the pickling is completed with less solution of iron. Additions of small amounts of common salt (sodium chloride) have a marked effect on increasing the rate of pickling of sulphuric acid baths. This is due to the formation of a corresponding amount of hydrochloric acid. The chief action of addition agents is to reduce the amount of acid vapor in the fumes from pickling vats and thus permit the use of highly efficient concentrations of acid (between 15 and 20%). Hydrogen absorbed by metals during pickling may be largely removed by immersing the metal in boiling hot water for a few minutes.

Gas-fired enameling furnaces for cast-iron. HENRY L. READ. *Jour. Amer. Ceram. Soc.*, **9** [12], 797–804.—A comparison is made of gas fired and electrically heated glass, enamel ovens. Description of equipment, data on output, fuel costs, and upkeep are given.

Defects in enamel due to cast iron. A. MALINOVSZKY. *Jour. Amer. Ceram. Soc.*, **9** [12], 805–13 (1926).—Microphotographic examination of iron on which enamel has pinholed, blistered, and come perfect are cited as evidence that carbon is practically the only agent in cast iron causing blistering and pinholing and that it is the condition and not the presence of carbon that causes these defects.

Antimony as a constituent of enamels. L. R. MERNAGH. *Chem. and Ind.*, **45**, 815–16 (1926).—Sb compounds employed in enamels are primarily Sb_2O_4 and to a less extent $NaSbO_3$, the latter costing twice as much as the oxide, and being less effective. Lead is barred from white enamels containing Sb owing to the production of Naples yellow. The opacifier is usually fritted with the enamel, though losses result through volatilization. This renders it more refractory, but brings its expansion nearer to that of iron. A further advantage is that by increasing the viscosity of the batch, it guards against devitrification. Like other opacifiers, the best result is obtained with minimum heat treatment. From the methods of preparation, Sb_2O_4 is likely to contain S, and $NaSbO_3$ to contain S, chloride, and sulphate, any of which will destroy gloss. M. does not agree with Grünwald that above 3–4% Sb renders an enamel of less covering power and more soapy and defective, nor does he accept G.'s dictum that the Sb be-

comes combined as silicate. He regards the opacifying effect as due to finely distributed alkali antimonates. He then debates the one real reason why the use of Sb is not universal in hollow-ware, *viz.*, the question of toxicity. There are no regulations forbidding its employment in England, Holland, or the U.S. The position in Germany is obscure, but Sb ware is certainly exported from Germany. Difference of opinion on toxicity is due to failure to distinguish between soluble and insoluble compounds, and between trivalent and pentavalent. Tartar emetic is peculiarly poisonous because it contains the stibonyl group, but if antimonates are to be excluded because tartar emetic is toxic, tin oxide should be condemned because soluble tin salts are toxic. The indirect evidence includes the fact that factories making Sb oxides have had men working for years without respirators, and no ill effects have been noted. M. then recounts his own experimental work after referring to Svagr's recent investigation (*Chem. Listy*, **20**, 21–24 (1926)), S. being of opinion that no ill effects have resulted from the prolonged use of antimony enamel. M. selected as basis a good commercial white enamel, above the average in SiO_2. Frits were made with increasing %, 1–10, of (*a*) Sb_2O_4, (*b*) $NaSbO_3$. Pie-dishes, 10½ in. diameter, in triplicate were enameled, the result in all cases being an excellent glossy finish. In these, 10% solutions of citric, acetic, and tartaric acids were kept gently boiling for an hour, the original volume being periodically restored with water. The acids were then cooled, nearly neutralized with KOH, rochelle salt was added, then excess $NaHCO_3$, and the liquid titrated against N/50 I. In all cases the gloss was destroyed by the treatment, the highest loss being 0.6 mg. Sb per sq. decimeter (whether Sb_2O_4 or $NaSbO_3$ enamel not stated). Lower strength acids and longer periods of action did not increase solubility. An enamel made from Rickmann's formula (*Sprech.*, **45**, 115) under the same treatment with 10% tartaric lost 31 mg. Sb per sq. dm. M. concludes that toxicity comes from As, and that pure Sb compounds in well-fritted enamels are absolutely safe. H.H.S.

Refinement of cast-iron by shaking. IRRESBEGER. *Engineering*, **122**, 249 (1926).—Practically all methods of refining cast-iron are based on thermal or chemical processes. A new mechanical process by J. Dechesne, of Rostock, consists in subjecting the liquid metal to a violent shaking motion, which activates and accelerates such reactions as are known to occur therein. The iron is degassed and deoxidized; the components of the iron are thoroughly mixed, thus neutralizing the harmful effects of S; graphite is dissolved, and a more finely-grained structure is obtained. The process is carried out with a cupola furnace to which is connected a receiver, pre-heated, the front end of which is raised and lowered 100 times a minute by cams. A slight horizontal motion, the receiver being carried in open bearings, "shakes" the liquid, as distinct from vertically "jolting" it, and the waves thus produced cause a lively evolution of gases, H, CO, SO_2, and a thorough mixing. H.H.S.

Anomalies in heat conduction in steel. C. BENEDICKS, H. BACKSTRÖM, AND P. SEDERHOLM. (Iron and Steel Inst. Stockholm Meeting.) *Engineering*, **122**, 302, 306–308 (1926).—Steel spheres were found to vary in thermal conductivity by as much as the ratio 1 : 8.5, the electrical resistivity difference being only 1 : 1.05. The authors consider that much of the heat transfer is occasioned by thermoelectric convection currents. The thermal conductivity (λ) of pure iron is given as 0.187, a result somewhat higher than that of other workers. The influence on λ of added dissolved elements is in the order: Ni, Mn, hardening C, Al, Si. Thus 1 atomic % of Ni lowers λ less than a similar quantity of Mn, and so on. H.H.S.

PATENTS

Burning rack. R. A. WEAVER. U. S. 1,610,111, Dec. 7, 1926. A burning rack ncluding spaced bars and cross pieces slidably mounted upon the bars.

Enameling metal articles. M. AUGER. Eng. Pat. 254,452, May 5, 1925. To produce a surface to which vitreous enamels will adhere on brass and similar yellow metal alloys, without the application of a copper coating, the alloy is treated with an acid (nitric acid, or a mixture of nitric and sulphuric acids, and / or a pickle (sodium chloride) to dissolve the metals, with the exception of the copper, from the surface. A practically pure copper surface is thus produced. (*Brit.C.A.*)

Glass

On the determination of the constitution of glasses. KOZO TABATA. *Jour. Amer. Ceram. Soc.*, 9 [12], 823–49 (1926).—This method of determination of the constituents of glasses is entirely new in its way. It is derived from the author's experiments on the causes of the surface devitrification of glasses. It is quite natural to produce crystals in glasses when heated several times at high temperatures. The glasses are supercooled liquids and are very viscous at low temperatures. But, when they are heated at higher temperatures, they attain low viscosities to produce crystals in them. In general, the chemical composition of the crystals produced (primary phase) in ordinary glasses without B_2O_3 is SiO_2. And for production of an elementary body of crystals of silica, there should be at least three neighboring molecules of silica moving within some ranges of speed. The motion of such molecules in glasses is set by two causes: the one is that quantity of energy given to the molecules by heating, and the other is that lowering of viscosity of the medium by heating. Heating glasses to certain temperatures is the exclusive cause of the crystal production of glasses. This has been already explained by many persons and no ambiguity has been left unsolved. The author has given another important cause for crystal production on glass surfaces and has described the interpretation. From these views, the author has arbitrarily defined devitrification in five degrees. They are seen in accompanying photographs. It has been determined that these degrees of devitrification were entirely coincident with the quantities of dissolved silica in glasses. The experiments have been conducted for a series of glasses of alkali silicates and alkali lead silicates. From the results of these experiments, the author has determined the constitutions of those silicates in glasses to be meta-disilicates and the double compounds to consist of those meta-disilicates. As the result of the determination of the constituents of alkali silicates and of alkali lead silicate glasses, it is pointed out that the compositions of crucibles to melt glasses of different silica content, should be either rich Al_2O_3 or rich SiO_2 according to the dissolving power of glasses for silica.

Sources of error in glass volumetric apparatus. H. V. E. M. RENN. *Jour. Amer. Ceram. Soc.*, 9 [12], 850–59 (1926).—The most serious source of error is the original calibrating operation. Errors introduced are due principally to following causes: (*a*) volumetric inaccuracy, (*b*) variation of bore, (*c*) delivery time, (*d*) incorrect marking of the meniscus, (*e*) after-working of the glass. Elimination of errors due to these causes is discussed. An apparatus for the calibration of volumetric apparatus is described. A source of error that is not usually recognized is the occurrence of after-changes in the glass during a period immediately following manufacture. The length of this period varies with the composition of the glass. Experiments by the writer upon glass volumetric apparatus show that a period of 7 months is usually sufficient in order to avoid excessive error from this source.

A Manchester glassworks. ANON. *Pottery Gaz.*, 51 [593], 1701–1706 (1926); *Glass Ind.*, 7 [12], 301 (1926).—A description of the glassworks of Butterworth Bros., Ltd., Newton Heaton. This firm is one of the few in England who can claim to manufacture fine table glass in addition to all kinds of glass for mechanical, scientific, and industrial purposes. E.J.V.

The Society of Glass Technology. ANON. *Pottery Gaz.*, **51** [593], 1709–14 (1926).—"Annealing of glass," a paper by James W. French was read and the following questions pertaining to annealing discussed: (1) the heat emissivity of the surface at all temperatures; (2) the thermal conductivity; (3) the thermal expansion or contraction of the glass; (4) cohesion; (5) viscosity; (6) existence of layers in the glass having different properties; (7) homogeneity; (8) forms and dimensions. Methods of detecting stresses in glass and the principles of annealing are outlined. Other papers read were: "A New Annealing Leer" by E. A. Coad-Pryor; "The Relationship between Chemical Composition and the Upper Critical Annealing Temperature of Glasses" by S. English. E.J.V.

The mechanical production of glass containers. ANON. *Pottery Gaz.*, **51** [593], 1724–30 (1926).—The development of mechanical methods of producing glass containers during the past 20 years is reviewed. Detailed discussions of the following sub-divisions of this field are given: (1) requisite properties for the production of flint glass, of amber glass; (2) drying the sand; (3) mixing, feeding batch into the furnaces; (4) glass compositions; (5) devitrification; (6) measurement of temperatures; (7) furnace design; (8) gas producers; (9) feeding devices; (10) automatic machines; (11) annealing. Compositions of typical hand-made glasses are given in contrast to compositions of glasses used on automatic machines and differences pointed out.

HAND BLOWN GLASSES

	Pale green	Pale green	Flint	Flint	Pale green
SiO_2	71.0	70.86	73.15	74.86	70.3
Al_2O_3	3.2	2.34	0.46	0.37	2.1
Fe_2O_3	0.4	0.25	0.05	0.06	0.3
CaO	15.3	16.57	15.00	14.58	14.2
MgO		1.01	0.14	0.32	0.5
Na_2O	10.1	8.97	11.20	9.81	12.6

GLASSES USED IN AUTOMATIC MACHINES

	Owens pale green	Miller press and blow pale green	Owens flint	Lynch amber	O'Neill flint	Graham pale green
SiO_2	73.62	74.01	75.21	71.19	74.06	72.0
Al_2O_3	1.92	1.08	0.35	3.52	0.33	2.1
Fe_2O_3	0.25	0.17	0.052	0.57	0.045	0.15
CaO	11.31	7.21	4.32	7.00	8.43	8.5
MgO	0.22	0.06	3.56	1.09	0.21	0.2
Na_2O	12.68	17.47	16.51	16.63	16.92	17.0

The advantage of the Owens machine in being capable of dealing with a large variety of glasses is shown by the extremes of compositions noted:

	Green	Green	Flint	Flint	Green
SiO_2	67.31	68.45	74.52	73.64	70.00
Al_2O_3	2.89	3.02	0.37	0.56	1.56
Fe_2O_3	2.50	2.83	0.06	0.06	0.75
CaO	15.21	14.52	3.21	5.18	16.45
MgO	0.51	0.79	2.46	1.75	1.35
MnO	0.35	1.98			0.34
Na_2O	11.23	8.41	19.38	18.81	9.55

E.J.V.

Glass for electrical insulation. ANON. *Pottery Gaz.*, **51** [593], 1742 (1926).—A glass of the following percentage composition is suitable for electrical insulators, according to a German firm applying for a British patent: SiO_2–67; K_2O–3; CaO–10; BaO–10; Fe_2O_3–10. E.J.V.

The preparation of plane surfaces. ANON. *Pottery Gaz.*, **51** [593], 1742(1926); *Nat. Glass Budget*, **42** [31], 21(1926).—See also *Ceram. Abs.*, **5** [10], 301(1926). E.J.V.

Describe new British bottle leer and conveyer. E. A. COAD-PRYOR AND F. A. HURLBURT. *Amer. Glass Rev.*, **46** [8], 15–16(1926). (Reprinted from *Pottery Gaz.*)—An experimental leer built after a consideration of methods of annealing in accordance with an ideal annealing curve is claimed to have the following advantages: (1) ease of control, (2) capability of handling large outputs, and (3) possibilities of future developments. The leer conveyer also being experimented with is designed to give movement for short steps, alternately horizontally and vertically, and is of such a construction as to eliminate loss of heat by conduction through the conveyer proper. This conveyer is only in the preliminary stages but shows promise of future developments. E.J.V.

The decomposition of glass. JAMES SCOTT. *Amer. Glass Rev.*, **46** [10], 15(1926). (Reprinted from *Glass.*)—Glass is liable to gradual deterioration as the result of slow decomposition of its constituents. That glass which is readily fusible is extraordinarily liable to decomposition. The chemical and mechanical influences of moisture, various atmospheric factors, and acids, etc., are the chief causes for this. Glasses containing alkalis are always susceptible while flint glass seems most immune from decomposition due to solution. Some minute formations observed are discussed. E.J.V.

Present paper on transmission of light through window glass. E. H. HOBBIE AND W. F. LITTLE. *Nat. Glass Budget*, **42** [30], 3(1926); *Amer. Glass Rev.*, **46** [8], 28(1926).—A note on a paper presented before the Illuminating Engineering Society. Data obtained in a study of window glass in a model were embodied therein. E.J.V.

Photo glass in Belgium. W. C. BURDETT. *Nat. Glass Budget*, **42** [30], 11(1926); *Amer. Glass Rev.*, **46** [8], 27(1926).—The immediate reason why all photo glass is not made mechanically is a matter of price, it being less profitable than glass made for windshields and railroad car windows. Prices are fixed by a glass association. E.J.V.

Blue glass used for welding. H. C. HOOVER. *Nat. Glass Budget*, **42** [30], 11(1926).—A blue glass has been developed by the Bureau of Standards which affords the proper contrast for use around metallurgical furnaces and also cuts out ultra-violet radiation. E.J.V.

Some ancient history on mirrors and early uses. ANON. *Nat. Glass Budget*, **42** [30], 16(1926).—The ancient history dealing with mirrors and their first introduction is traced according to the works of Aristotle, Pliny, Plutarch, and others. E.J.V.

Adamston Flat Glass Company has model plant. ANON. *Nat. Glass Budget*, **42** [31], 3(1926).—A description of the sheet glass drawing machines and other accessory mechanical devices used in this modern factory at Clarksburg, W. Va. E.J.V.

Story of glass in early ages. W. M. FLINDERS-PETRIE. *Nat. Glass Budget*, **42** [31], 16–17(1926). E.J.V.

Origin of iridescent glassware; its discovery and manufacture. ANON. *Nat. Glass Budget*, **42** [31], 19(1926).—Iridescent glass is a modern discovery, the result of fortuitous circumstances, when vapors of fireworks used in a furnace where glassware had been placed produced the peculiar color. This occurred in 1858 in Zlatno, Hungary. Old formulas for mixtures to produce various colors are given. E.J.V.

Thuringian glass. F. ECKERT. *Glastech. Ber.*, **3** [12], 435–44(1926); *Chem. and Ind.*, **45B**, 746(1926).—The reputation of Thuringian glass is due to its ease of working and stability before the lamp. These result from a high general alkali content with relatively much potash, and the presence of alumina (introduced by the use of felds-

pathic sand). The chemical resistance of the glass has been improved by reducing the alkali, increasing the alumina, and adding boric oxide. The credit for this is due the firm of Schott & Gen. The production of "Normal" thermometer glasses 16III and 59III was a result of Weber's discovery of the effect of the simultaneous presence of two alkali oxides in promoting thermal afterworking. The average percentage compositions of the 3 chief types of Thuringian glass are: (1) apparatus glass: SiO_2 68.5, Al_2O_3 3.2, Na_2O 14.2, K_2O 6.3, CaO 7.1; (2) packing and medical glass: SiO_2 68.7, Al_2O_3 3.9, Na_2O 17, K_2O 3.8, CaO 7.4; (3) Christmas ware; SiO_2 68, Al_2O_3 3.1, Na_2O 22, K_2O a trace, CaO 7.2; all contain small amounts of As_2O_3, Mn_2O_3, NiO_2, and Fe_2O_3. Examination of glasses from some 30 factories indicated that 80% were of low chemical stability and fell in group V of the Reichsanstalt classification. None of the glasses of types (2) and (3) reached group IV and of type (1) only one sample fell in the soft apparatus and one in the hard apparatus class. Difficulty of joining samples of glass is due to a difference of past heat treatment rather than to a difference of composition. An appearance of color on heating may be caused by the presence of the oxides of arsenic, antimony, zinc, or iron in the glass. Roughening of the glass in the flame, attributed to devitrification and to volatilization of alkali, may be produced by colloidal separation. The phenomenon is hindered by replacement of silica by alumina, by basic earths, or, other things permitting, by alkali. E.J.V.

A new ultra-violet transmitting glass. H. P. Hood. *Glass Ind.*, **7** [12], 287–88 (1926). —A new glass, transmitting to 200$\mu\mu$ in three mm. thickness, and 86% for wavelengths of 280$\mu\mu$ through two mm. thickness has been developed at Corning Glass Works. It has a density of 2.64, a refractive index for the D line of 1.539, a dispersion of .009 for $N_f - N_c$, a linear expansion coefficient of nearly .041 and possesses a stability within the range of ordinary glasses. The cost of producing the glass is a little above that of window glass but far below that of fused quartz. E.J.V.

Protecting the eyes against ultra-violet rays. Louis Stoess. *Glass Ind.*, **7** [12], 288 (1926).—The harmful effects of ultra-violet rays on the eyes are discussed and the use of protective glass for making electric light bulbs is advocated. E.J.V.

Otto Schott. Hans Götze. *Glass Ind.*, **7** [12], 291–92 (1926).—A biographical sketch of the life and work of Dr. Schott, founder of modern glass technology, who recently celebrated his 75th birthday. E.J.V.

Problems of the glass industry presented before Montreal S.C.I. Robert J. Montgomery. *Can. Chem. Met.*, **10** [12], 288 (1926).—A brief note on "Present Day Problems of the Glass Industry" presented by M. E.J.V.

Fused germanium dioxide and some germanium glasses. L. M. Dennis and A. W. Laubengayer. *Jour. Phys. Chem.*, **30** [11], 1510–26 (1926); *Nat. Glass Budget*, **42** [30], 3 (1926).—Equi-molecular amounts of germanium dioxide were substituted for SiO_2 in preparing light flint, crown, barium crown, and borosilicate glasses. These glasses have higher refractivity and dispersion than the silicate glasses. They also have about the same transmission in the visible and infra-red regions and lower than silicate glasses in transmission of ultra-violet. Partial dispersion ratios of germanium and silicate glasses are about equal. The germanium glasses have greater density and expansivity, about the same hardness and lower softening temperatures. They devitrify somewhat more readily but are more easily fined. Their durability and probable resistance to weathering are not markedly lower than that of silicate glasses. Because their optical properties differ so widely from those of corresponding silica glasses they can probably be advantageously used in optical systems. L.A.P.

Society of Glass Technology studies annealing processes. Anon. *Ceram. Ind.*, **7** [6], 670 (1926).—The following questions are discussed: (1) Rate at which heat is dissipated by glass at various temperatures of the annealing process; (2) thermal

expansion of glass; (3) thermal conductivity of glass; (4) cohesion of the material; (5) viscosity; (6) the existence of a surface layer having properties different from those of underlying material; (7) homogeneity of glass; (8) form and dimensions of the glass. Economics of annealing was discussed. F.P.H.

The transmission factor of commercial window glasses. A. K. TAYLOR AND C. J. W. GRIEVESON. Dept. of Scien. and Indus. Research (Illumination Research), *Tech. Paper*, No. 2 (1926).—Absorption of light by clean window glass is sometimes regarded as negligible for practical purposes. Hitherto but little information has been available as to extent of absorption in various special glazing. The daylight illumination at any given point in a room of definite design depends on three factors: (*a*) The brightness of those parts of the sky and other bright surfaces which are visible from the point in question, (*b*) the amount of light transmitted by the glass in the window, and (*c*) the reflecting power of the walls and ceiling of the room. This report discusses the 2nd of these 3 factors and describes measurements made at the Natl. Phys. Lab. with the object of determining the transmission factors, under various conditions, of a number of different kinds of glass commonly used for the windows of domestic and industrial buildings. The results show that for diffused light incident from the 45° lune, ¼-inch plate glass transmits 77 % compared with 84 % for light incident from a half-hemisphere; for diffusing glasses rough-rolled and wired cast the transmission factor is 67½ and 62 % compared with 76 and 70½ %, respectively. For the prismatic type of glass the 60° prismatic transmits 73 % with its smooth side facing the light and its prisms orientated. If this glass is arranged so that the ribbed surface faces the light the transmission is reduced to 65½ %. The 45° prismatic appears to transmit better with its ribbed surface toward the light, the transmitting factor being some 66 %. In comparing the results obtained for the prismatic glasses it should be noted that the transmission factor is merely the ratio of the total transmitted to the total incident light flux and takes no account of the light distribution. In an appendix to this report J. W. T. Walsh discusses further "The reflection factors of a polished glass surface for diffused light." O.P.R.O.

Industrial research laboratory at Calcutta, India. ANON. *Chem. Age*, **15**, 398 (1926). —The laboratory founded by the Government is conducting research on problems connected with the glass, soap and oil, and paint and varnish industries. H.H.S.

Thermometer testing. NATL. PHYS. LAB. *Engineering*, **122**, 113 (1926).—A marked increase in the number of precision thermometers submitted for tests is largely due to the specifications laid down by the Institute of Petrological Technologists. The quality of glass is well maintained, but the divisions are sometimes extended to high temperatures at which the glass is not satisfactory. Silica tubes are not uniformly fine in bore. The use in spirit thermometers of methyl alcohol containing even 0.5% acetone is deprecated. Thermometers made to contain 50% each of acetone and methyl alcohol were 14°F out in 2 months, and 60° in 14 months. H.H.S.

Aging of glass. NATL. PHYS. LAB. *Engineering*, **122**, 114 (1926).—Information upon the effect of aging on some types of glass was obtained by spectrophotometric measurements on 12 representative glasses made by Chance Bros. H.H.S.

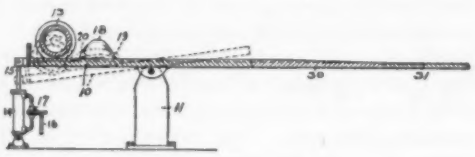
Fused quartz insulators. NATL. PHYS. LAB. *Engineering*, **122**, 115 (1926).—The high-tension insulators of fused quartz which the N.P.L. adopted a few years ago in preference to sulphur, apparently with the best results, have been found under certain conditions to deteriorate rapidly. The deterioration may be prevented by cleaning the quartz with acid, then making it red hot and dropping it into melted paraffin wax, the superfluous wax being allowed to drain off. The standard condensers fitted with these insulators have the lowest power factors of all the condensers of the department. H.H.S.

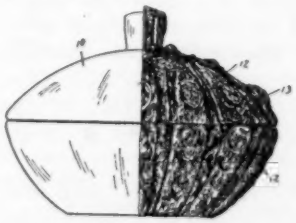
PATENTS

Apparatus for feeding molten glass. J. R. KELLER. U. S. 1,608,601, Nov. 30, 1926. Apparatus for feeding molten glass comprising a receptacle for molten glass having a downwardly opening discharge orifice, shears disposed below the discharge orifice, and a shaping receptacle disposed below the shears, the receptacle being composed of two superposed portions, the lower portion having downwardly converging inner walls and means for cooling the shaping receptacle.

Device for discharging molten material. F. H. LOBB. U. S. 1,608,603, Nov. 30, 1926. In a device of the character described, a main furnace having an outlet, an auxiliary tank connected with the outlet and provided with a discharge nozzle, means for controlling the nozzle, a heating jacket for the auxiliary tank, a channel connecting the upper portion of the jacket with the interior of the main furnace, above the tank, and a removable cover forming a top wall for the channel. In a glass feeding machine, a glass container having a discharge outlet, a shearing device for periodically severing the discharged glass, a cam mechanically connected to operate the shearing device, and means for adjusting the cam while the machine is operating, to change the time during which the shearing device is away from its position directly beneath the outlet, and thereby to change the dimensions of the charges severed.

Method of and apparatus for forming sheet glass. G. E. HOWARD. U.S. 1,608,657, Nov. 30, 1926. The step in the process of forming sheet glass which comprises depositing a mass of molten glass upon the lower portion of an inclined surface, and then tilting the surface to reverse the direction of incline and thereby cause the glass to flow toward the opposite end of the surface.

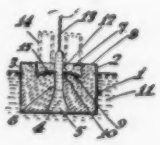




Decorated glassware and process of making same. H. J. RANSBURG. U.S. 1,608,670, Nov. 30, 1926. A decorated article comprising a base form, and a contracting non-transparent composition applied to the surface thereof so as to be rigidly secured thereto upon its contraction, the composition having its surface formed in artistic designs in relief.

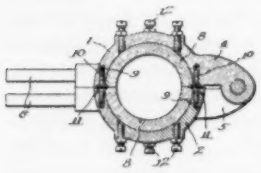
Glass-feeding apparatus. JAMES MORRISON. U. S. 1,608,710, Nov. 30, 1926. A machine for the handling of molten or plastic material comprising a chamber for containing the molten or plastic material, an agitator member in the chamber for agitating the plastic material, an auxiliary pre-heating chamber and an auxiliary agitator member in the pre-heating chamber, both of the agitator members being arranged for transfer from and to the chambers.

Method and apparatus for treating sheet glass. H. C. METZGAR. U.S. 1,609,266, Nov. 30, 1926. An apparatus for drawing glass comprising a drawing block of refractory material, the block having a surface against which the glass contacts and a heat insulating material adjacent the surface adapted to reduce heat radiated from the block.



Glass composition. W. C. TAYLOR. U. S. 1,609,329, Dec. 7, 1926. A glass substantially free from silica, and containing boric oxide, alumina, an oxide of a second group element, and not over 10% alkali, of which more than one-half is potassium oxide.

Glass-working apparatus. R. W. CANFIELD. U. S. 1,609,691, Dec. 7, 1926. In a glass-working machine, the combination of two glass-working units, each having a rotatable spider carrying a plurality of glass-working units, mechanism for intermittently turning the units alternately in opposite directions, mechanism for locking each unit between its movements, a single driving mechanism for actuating the unit rotating mechanisms, and manually controlled means for stopping the effective operation of the mechanisms of either units without affecting the operation of the mechanism of the other unit.



Glass mold. B. C. GILLIGAN. U.S. 1,609,707, Dec. 7, 1926. A glass mold comprising a metal shell, a composition lining, and means separable from both the shell and lining connecting the parts and preventing relative movement between them in any direction.

Method of making glass molds. B. C. GILLIGAN. U. S. 1,609,708, Dec. 7, 1926. The hereindescribed method of constructing molds for glass articles comprising affixing a composition lining to the inner surface of a metal shell, and then shaping the lining to conform to the contour of the article to be molded.

Drawing sheet glass. E. T. FERNGREN. U. S. 1,609,998, Dec. 7, 1926. A sheet glass drawing apparatus comprising a receptacle for the molten glass from which the sheet is drawn, the receptacle being closed at one end and in open communication at the other end with a source of molten glass, the receptacle being deeper at the open end than at the closed end, and its bottom wall being thicker at the deeper end and thinner at the shallower end, in combination with a heating chamber above which the receptacle is supported.

Drawing sheet glass. E. T. FERNGREN. U. S. 1,609,999, Dec. 7, 1926. In sheet glass apparatus, a tank furnace containing a mass of molten glass, a draw-pot in open communication therewith, the wall at the closed end of the draw-pot being of such a height as to permit a constant overflow of glass from the draw-pot, and means for drawing a sheet from the glass in the draw-pot.

Drawing flat sheet glass. L. A. GROLEMUND. U. S. 1,610,004, Dec. 7, 1926. In apparatus for producing sheet glass, a cooler positioned transversely of the glass sheet, and comprising a longitudinal series of separately regulatable sections.

Sectional lip tile. N. MAMBOURG. U. S. 1,610,103, Dec. 7, 1926. In a sheet glass apparatus, means for drawing a sheet from a mass of molten glass, and a lip-tile arranged above the molten glass and comprising a body portion and a removable lip portion.

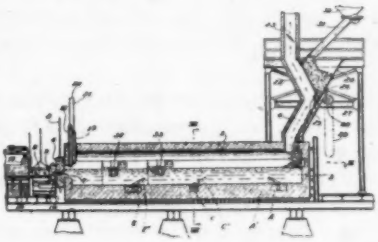
Grinding and polishing table. F. E. TROUTMAN AND C. H. CHRISTIE. U. S. 1,610,184, Dec. 7, 1926. Apparatus for grinding and polishing flat glass comprising two sets of tracks arranged in alignment with each other and of different gages and at different heights, and a plurality of grinding or polishing tables each having front and rear wheels adapted to run upon one of said tracks and having auxiliary wheels adapted to run upon the other track, the table having means for causing the end of each table adjacent to the auxiliary wheels to support the end of an adjacent table when the tables rest upon the auxiliary track.

Apparatus for making plate glass. FREDERICK GELSTHARP. U. S. 1,610,367, Dec. 14, 1926. In combination, a glass tank containing a body of molten glass, an outlet member seated in the glass from above, and having a vertical outlet slot therethrough, a pair of driven and cooled sizing rolls above the slot extending longitudinally of the slot at the outlet end thereof adapted to receive the glass and size it, and a glass receiving

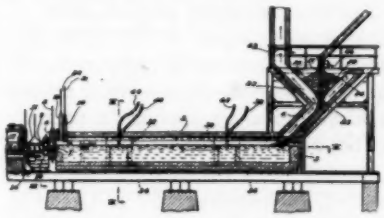
bed extending laterally from the side of one of the rolls for carrying away the glass which is formed.

Apparatus for cleaning plate-glass-grinding tables or cars. H. S. HEICHERT AND A. E. EVANS. U. S. 1,610,374, Dec. 14, 1926. Apparatus for cleaning plaster from tables mounted for movement along a track, comprising a rotary brush extending across the track and provided with radially extending metallic fibers, an adjustable tilting frame carrying the brush and power means for rotating the brush at a high rate of speed so as to cut the plaster from the tables as they pass beneath the brush, the power means being supported from the frame.

Process and apparatus for making glass. H. F. HITNER. U. S. 1,610,376, Dec. 14, 1926. In combination in apparatus for making glass, a tank having bays in its side walls, electrodes at the inner ends of such bays, and means for supplying current to the electrodes.



Apparatus for making glass. H. F. HITNER. U. S. 1,610,377, Dec. 14, 1926. In combination in apparatus for making glass, a melting tank arranged to receive batch at one end and deliver molten glass at the other end, a plurality of electrodes in the bottom of the tank along each side thereof in spaced relation and each comprising a pool of molten metal, and means for supplying current to the electrodes so as to cause the flow thereof to pass through the glass longitudinally of the tank.



Process for surfacing sheet material. CHRISTOPHER BROWN. U. S. 1,610,419, Dec. 14, 1926. A process for surfacing a sheet of material, which consists in supporting it and moving it forward horizontally in a right line, and during such movement, first abrading the surface with an abradant carried under pressure in a circular direction over the surface until a flat smooth surface is secured; second, further abrading the surface with an abradant of a finer grade carried over the surface in the direction of movement of the sheet, but with decreased pressure and at an increased speed as compared with the pressure and speed of the first abradant so as to produce a semi-polish; and third, polishing the surface with rouge applied in a circular direction.

Apparatus for making sheet glass. J. S. GREGORIUS. U. S. 1,610,443, Dec. 14, 1926. The combination with a receptacle for molten glass, and a drawing means thereover for drawing a glass sheet continuously from the bath, of a cooling device extending across the bath on each side of the sheet adjacent the surface of the bath, and comprising a hollow shell, such shell having its central portion formed from a material having a higher degree of conductivity than the material from which the end portions are formed, and means for circulating a cooling fluid through each of the shells.

Method of making refractory glass. T. A. O'SHAUGHNESSY. U. S. 1,610,581, Dec. 14, 1926. A method of making smooth-surfaced refractory glass characterized by providing separate layers of transparent glass of different densities having complementally formed uneven light-refracting sides, a layer having a smooth exterior surface opposite its uneven surface; superposing the layers with their complementally formed sides interfitted; and integrating the layers by fusion of their contacting surfaces.

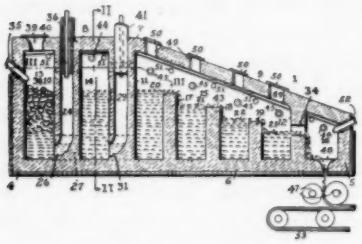
Glass-polishing apparatus. C. H. CHRISTIE. U. S. 1,610,658, Dec. 14, 1926. Glass polishing structure comprising an annular block, a ring-like member adapted to loosely surround the block, a polishing pad, means for securing the pad to the ring-like member, comprising a band disposed concentrically of the member and serving to clamp the pad against the same, and means for detachably securing the ring-like member to the block.

Method of and apparatus for forming glass articles. D. A. RIPLEY. U. S. 1,610,883, Dec. 14, 1926. Apparatus for forming glass articles, comprising a receptacle rotatable in a horizontal plane, a plurality of molds rotatable in a plane beneath the first plane and co-axially with the rotatable receptacle, and means for delivering mold charges from the receptacle to the molds, the receptacle rotating only in the same direction as the molds.

Timing mechanism for glass feeders. K. E. PEILER. U. S. 1,611,063, Dec. 14, 1926. In a timing device for a glass feeder or the like, the combination with a source of fluid pressure, of a control valve having a valve member movable back and forth between open and closed positions, a rotary actuating member for opening the valve, another rotary actuating member for closing the valve, both of the rotary actuating members being rotatable in the same direction and upon the same axis, and gearing, manually operable while the actuating members are rotating, for changing the angular position of either of the actuating members independently of the other.

Method of making laminated glass. LOUIS BARTELSTONE. U. S. 1,611,139, Dec. 14, 1926. The art of making laminated glass which consists in applying to the surface of a flexible film a coating of vegetable oil devoid of solvent properties toward the material of the film; and then affixing the film to glass by applying a pressure adequate to squeeze out all appreciable excess of the oil and maintaining the pressure at an elevated temperature for a short time.

Method and apparatus for manufacturing glass. J. I. ARBOGAST. U. S. 1,611,328, Dec. 21, 1926. A method of manufacturing glass consisting in passing a molten body of glass over a series of dams of different heights to provide a kneading action on the body to harmonize the molecules thereof and at the end of the kneading action on the body subjecting it to a cold blast to bring the body to an annealing temperature. An apparatus for manufacturing glass comprising a melting chamber, a refining chamber communicating therewith, a kneading chamber provided with a series of open top collecting compartments progressively decreasing in height from the refining chamber, means for establishing communication between the refining chamber and the collecting compartment of greatest height, a discharge chamber, and means for establishing communication between the discharge chamber and the collecting compartment of less height.



Adjustable glass feeder. FRANK O'NEILL. U. S. 1,611,362, Dec. 21, 1926. A container for a pool of molten glass, the container being provided with a bottom opening, a plunger, a control device for the plunger embodying an actuator for the plunger, and a stop for the plunger as to which the container is adjustable independently of affecting the stop as coacting to limit the plunger movement there-toward, the actuator comprising an adjustable lost motion transmission device to effect adjusted lifting of the plunger away from the stop.

Press-ware manufacture. FRANK O'NEILL. U. S. 1,611,363, Dec. 21, 1926. A continuous rotation driving shaft, a table, transmission means between the shaft and table, a mold carried by the table, a plunger for entering the mold, and driving connections independently of the transmission means from the shaft for shifting the plunger in a plane parallel to the plane of the table.

Heavy Clay Products

Flashing brick in a tunnel kiln. ANON. *Brick Clay Rec.*, **69** [11], 810 (1926).—A description of the new plant of the Michigan Clay Products Co. The kiln is a Harrop car tunnel kiln, open fire, 367 ft. long. Flashing is done by the last 2 fire boxes on the kiln. It is accomplished by shutting off a portion of the air coming from the discharge end of the kiln and admitting air through the oxidation flues between the 6th and 7th fire boxes. In order to get an excess of fuel into the kiln to produce the flash, arrangements have been made to spray oil into the kiln on each side of the last 2 fire boxes in addition to that fed through the burner. This oil is blown in with the aid of a strong air blast, which also prevents the gases under pressure in the kiln from backing up through these spraying-mixtures. According to the plant officials, colors can be produced at will, as the flashing can be controlled to a very accurate degree. F.P.H.

Steel makers propose fireproofing specifications. ANON. *Brick Clay Rec.*, **69** [11], 817 (1926).—Proposed specifications of the American Institute of Steel Construction relating to the efficiency of fireproofing and better methods of fireproofing steel. These specifications are of particular interest to hollow tile manufacturers. F.P.H.

Bureau of Standards to test 200 brick walls. ANON. *Brick Clay Rec.*, **69** [12], 907 (1926).—The program for measurement of the strength of brick work being carried out in coöperation with the Common Brick Manufacturers Association will involve construction, aging, and testing of about 200 brick walls before the investigation is complete. The investigation covers 4 grades of brick, 3 mortars, and 2 grades of workmanship as well as several novel methods of constructing walls, such as the Ideal brick wall. F.P.H.

Firing flashed brick in Michigan. ANON. *Clay-Worker*, **86** [5], 373–79 (1926).—Description of the modern stiff mud plant of the Michigan Clay Products Co. which produces face brick, burning with oil in tunnel kiln. F.P.H.

The evolution of brick and brickmaking in the United States. GEORGE M. FISKE. *Clay-Worker*, **86** [5], 382–85 (1926).—The 7th of a series of articles on this subject. This chapter treats of skintled brickwork. F.P.H.

Scumming and efflorescence, causes and prevention. L. P. COLLIN. Can. Dept. of Mines, Mines Branch. *Invests. of Ceram. Mats.*, 1926.—The terms scumming and efflorescence are used with different meanings by authorities on the subject; the most commonly accepted definitions are those given by Jackson in his "Descriptive Bibliography of Scumming and Efflorescence." They are: Scumming—The formation on the surface of a ceramic body of a deposit of foreign matter during the process of manufacture. Efflorescence—The formation on the surface of a finished ceramic ware of a deposit of foreign matter due to exposure to weather. It is believed that the use of the terms, as so expressed will tend to avoid misunderstanding and confusion by allowing a sharp dividing line to be drawn between the 2 without imposing limitations as to solubility. Scumming occurs during process of manufacture and efflorescence occurs on the finished product. There are many causes of scumming; the 5 following may be considered the most important: (1) soluble salts in the raw material; (2) soluble salts in tempering water; (3) scum developed from the lubricating oils; (4) scum developed

in drying and water-smoking; (5) scum developed during the firing. Soluble salts are the cause of nearly all scum; if they are present in the raw materials they must not be allowed to form a deposit on the surface of the ware. One way is to remove same, another is to render the soluble salts insoluble. Fast drying is a method of prevention which has proven successful in many cases of scum. The best method of preventing scum being developed in the drier is to eliminate the sulphur gases. Kiln scum caused by sulphur and the lime compounds in ash may be overcome by avoiding the use of wet, dirty fuel. Efflorescence, which appears on the finished product after it has been taken from the kiln and exposed to the weather, has been the subject of much discussion, and research work accomplished as far from complete. It is caused by soluble salts in the ware being brought to the surface and deposited by the evaporation of water; it is also caused by soluble salts being transferred from mortar or from stone copings; and in wares stored on the ground it may be caused by the soluble salts in the soil being transferred to the ware. The salts which cause most of the efflorescence are the sulphates of magnesium, sodium, and potassium. Efflorescence may be checked by hard firing and by firing with a reducing atmosphere. The hard firing will increase the stability of the silicates and make a stronger bond so that weathering will not be likely to cause soluble salts to be formed. Furthermore, by increasing the fluxing action of the more fusible compounds, hard firing reduces the number of open and directly communicating pores.

Summary

Causes of Scumming	Methods of Prevention
Soluble salts in raw material	Weathering, if pyrite is not present Barium salts Fast drying
Soluble salts in tempering water	Barium salts Fast drying
Formation of sulphates in drier	Elimination of sulphur gases Barium salts
Formation of sulphates in kiln and deposition of sulphates formed in drier	Water-smoking with non-sulphurous fuel Alternating reducing and oxidizing conditions Use of clean, dry fuel
Causes of Efflorescence	**Methods of Prevention**
Soluble salts in firing ware	Hard firing Reducing conditions
Soluble salts absorbed from mortar, stone copings or ground	Keep from contact with brick, and secure proper drainage from stone copings
Soluble salts formed by weathering	Hard firing Alternating oxidizing and reducing conditions

Scumming and efflorescence may be overcome, or at least checked, in practically every case, if the cause be determined and the above methods of prevention intelligently used. O.P.R.O.

Brick and tile industry. ANON. Manitoba Industrial Development Board, *Official Report*, 1926.—There are 2 sources of materials in Manitoba for the brick and tile industry: the surface clays and the cretaceous shales and clays. The surface clays are the exclusive raw materials used at the present time; all the brickworks established to operate on the older clays have been dismantled. The present demand for common bricks is being met by 5 brick works. Hollow brick, hollow tile, and drainpipes are produced in the province of Manitoba. No clay products of higher grade, such as

fire brick or pottery ware have been produced. A fairly refractory brick may be obtained from Swan River Valley. Refractory clays for firebrick and pottery ware have not been found in Manitoba, except a limited occurrence of kaolin, on Little Deer Island, Lake Winnipeg. Ample raw material is available for common brick, and indications are that all but the most exclusive demand in face brick will be supplied from sources within the province as well. O.P.R.O.

BOOK

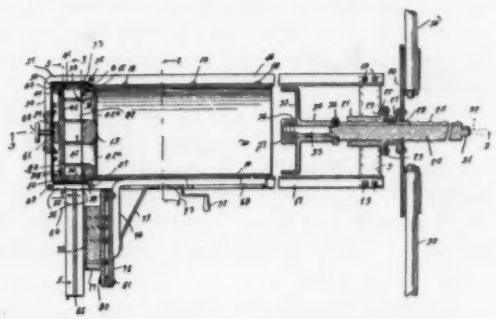
Permeability to water vapor and heat. NATL. PHYS. LAB. *Engineering*, **122**, 113 (1926).—Permeation of water vapor through building material is tested as follows: A tray containing $CaCl_2$ is suspended inside a cell made of the material by a wire from one scale of a balance; the wire is introduced through a fine glass tube passing through the top of the cell, both ends of which are closed by impermeable walls. The increase of weight indicates the rate of diffusion of vapor, which is found to be rapid at first. In heat-transmission tests through walls of insulating materials the following results expressed in B.t.u. per sq. ft. of surface in 24 hrs. for 1°F difference between the 2 faces, were obtained: London stock bricks in cement, 9 in. thick, 16.3; composite concrete walls of breeze blocks with gravel concrete between, 7 in. thick, 20.2; composite cork and concrete, total thickness 6.1 in., 5–5.5 units. H.H.S.

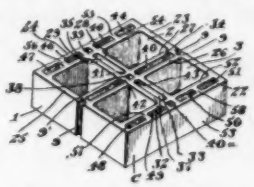
Klinkers: Their Employment and Production. KARL DÜMMLER. Published by Wilhelm Knapp. Reviewed in *Clay-Worker*, **86** [5], 381 (1926). F.P.H.

PATENTS

Method of making brick and other fired clay products. POOLE MAYNARD. U. S. 1,609,416, Dec. 7, 1926. The process of making brick and other fired clay products which comprises firing a mixture of clays to produce a product having an iron oxide content from 2½ to 3½% and less than 25% of lime at a temperature above 2000°F.

Tile-molding machine. JOSEPH KOBERLING. U. S. 1,610,952. Dec. 14, 1926. In a tile molding machine, a tile mold, a backing for the mold, means for feeding plastic material into the mold, means to permit lateral shifting movement of the mold, means for ejecting the tile from the mold, the feeding means including a cylinder, a plunger reciprocable in the cylinder, a screw block mounting for the plunger, a screw rod carrying the plunger working in the block, manually operable means having a splined connection with the screw rod and rotatably interlocked with the screw block for operating the rod and plunger, a sleeve bearing forming a part of the plunger through which the rod is journaled, thrust bearings between the rod and plunger, and a guide head at the forward end of the feeding means having openings therein corresponding to the tile mold openings for directing the plastic material into the mold.





Hollow brick or building tile and wall structure. G. D. REAGAN. U. S. 1,611,373, Dec. 21, 1926. A substantially square building unit having a plurality of large voids defined by the outer walls of the unit on 2 sides thereof, 2 of the opposite outer walls being of double thickness with voids therein, the other walls of the voids being webs

intersecting at the center of the unit and having smaller voids, one at the mid-point of intersection, the opposed thinner outer walls each having a parallel-sided kerf extended across the outer face thereof opposite the adjacent smaller voids.

Refractories

Refractories for oil-gas manufacture. H. J. KNOLLMAN. *Jour. Amer. Ceram. Soc.*, 9 [12], 860–87 (1926).—The present investigations of refractories by the oil-gas industry on the Pacific Coast were stimulated by sporadic independent tests in the past whereby it was observed that different qualities of fire brick not only had varying lengths of service but also had an apparent influence on the amount and quality of gas made and on the efficiency of gas manufacture. The essential differences in generator design, including that of brickwork construction, in the two-shell type of generator as compared with the single-shell generator are such that longer refractories life is obtained in the former type. The operations in the manufacture of oil gas for the two-generator types are briefly discussed, showing that the refractories are subjected to alternating oxidizing and reducing conditions. Other causes contributing to ultimate refractories failures are carbon deposition in the brick, abrasion of hot gases, and the impinging of long flames on the brick, heavy checkerbrick loads on arches, faulty construction of arches, and erratic working conditions. In addition, super-saturated steam, heavy hydrocarbons, and salts and sulphur in the oil, are contributing causes to checkerbrick disintegration, especially in the generator zones where the oil and steam are introduced. It is hoped that specifications for refractories may be drawn up from the results of practical service tests now being conducted. The heat-transfer and heat-absorption properties of various refractories, such as conductivity, specific heat, density, diffusivity, heat capacity, and time required for the refractories to reach near-heat saturation, are discussed, particular attention being given to their possible application as oil-gas generator checker brick. The need for more complete and accurate data on the fundamental constants necessary in heat-transfer calculations is pointed out. Researches on refractories with thermal properties superior to fire brick are now being conducted in generators in an endeavor to increase gas capacity and operating efficiency along the lines indicated by theoretical considerations.

Sagger symposium. Led by A. V. BLEININGER. *Bull. Amer. Ceram. Soc.*, 5 [12], 445–59 (1926).—A very complete discussion of saggers and sagger bodies along the following sub-divisions: (1) thermal expansion; (2) some successful cone 10 sagger bodies; (3) sagger clays and properties; (4) notes on tests with various grog materials; (5) questions and notes. Under the last sub-division, some fifteen questions are answered. Much information is presented on observations by various manufacturers and technical men. E.J.V.

Are more durable tank blocks wanted? S. R. SCHOLES. *Glass Ind.*, 7 [12], 283–84 (1926).—The question of how far glass manufacturers would be willing to go in buying superior tank blocks is discussed. A statement of the related factors entering into the problem of profitable investment in furnace walls is presented. It is concluded that the purchase of improved tank blocks at a cost in proportion to their durability will be found profitable. The consensus of opinion of several other glass manufacturers is to the same effect. E.J.V.

Mullite refractories. L. S. LONGENECKER. *Glass Ind.*, 7 [12], 285–86 (1926).—A review of a paper presented by T. S. Curtis before the Pittsburgh Branch of the AMERICAN CERAMIC SOCIETY, November 3, 1926. E.J.V.

Sagger marls and sagger making. ALEXANDER SCOTT. *Pottery Gaz.*, 51 [593], 1715–17 (1926).—Clays or marls used for sagger making in North Staffordshire are

discussed. Some of the problems which arise when these materials are utilized for sagger making were: (1) load-supporting ability of the saggers; (2) selection of grog for use in saggers; (3) firing of "green" saggers; (4) thickness of sagger walls; (5) some causes of dunting; (6) aging and weathering of clays; (7) storage of grog; (8) iron on the clays. E.J.V.

The effect of slag in blast furnace gases on the melting point of fire clays with varying alumina contents. FRITZ ILLGEN. The refractories in the checker work in regenerators are subjected to temperatures varying from 500° to 1400°C as the air and gas currents are changed in direction of flow through them. While the brick may be of varying quality, with the highest grade in the upper zone and the poorer grade at the bottom of the regenerator, the factor that the slag, rich in fluxes, carried by the blast furnace gases has an effect on the refractory must not be overlooked. With this in mind, 6 different fire clays having the following alumina contents were obtained: (1) 26.20%, (2) 30.26 %, (3) 33.65 %, (4) 36.41 %, (5) 38.70 %, and (6) 42.78 %. A slag of the following composition was used: alkalis, 11.98 %; FeO, 0.52 %; Fe_2O_3, 1.63 %; SiO_2, 28.40 %; MnO, 2.36 %; P_2O_5, 0.13 %; SO_3, 4.73 %; Pb, 0.61 %; Zn, 11.97 %; Al_2O_3, 11.76 %; CaO, 10.01 %; CaS, 5.78 %; MgO, 8.60 %; ignition loss, 1.30 %. The clays were pulverized and mixture made with slag contents of 0, 10, 20, 30, 40, and 50 %. These were made up into cones and melting point determined on each. Results obtained show that increasing amounts of slag lower the melting point of the clay until an addition of 50 % brings it to the melting point of the slag itself. Also, it was noted that the clays with 39 to 43 % Al_2O_3 showed the best resistance. From the results of this investigation it is obvious that in the upper zones of regenerators dense, highly aluminous refractories are necessary when there is a slag rich in fluxes present in the furnace gases. A slightly inferior grade of refractories, possessing the necessary load carrying qualities, may be used in the zone with temperature under 1000°C. E.J.V.

Determination of the thermal conductivities of insulation for temperatures up to 1000°F on other than flat surfaces. R. H. HEILMAN. *Mech. Eng.*, **48** [11a], 1297 (1926). —H. deals with non-metallic materials used primarily for pipe coverings in connection with temperature from 100° to 1000°F. Two main objects are pointed out (*a*) to review the literature, (*b*) to deduce what is lacking in the apparatus used and values obtained, and to suggest what should be done to obtain accurate and reliable apparatus. H. believes that laboratory tests are of great importance and should be conducted wherever possible before the practical large scale test. The temperature drop from air-insulated steam lines to the surrounding air is made up of 5 distinct items: (*a*) the drop from the steam to the inner surface of the pipe; (*b*) the drop through the pipe wall; (*c*) the drop from the outer surface of the pipe to the inner surface of the insulation; (*d*) the drop through the insulation; (*e*) the drop from the outer surface of the insulation to the surrounding air. Methods are described for determining the importance of each drop. Apparatus for the measurement of each item is described. A description of apparatus used in testing heat-insulating cements and a number of results of practical tests are given. A bibliography of investigational work together with a discussion of each article is given. C.J.H.

An investigation of boiler-furnace conditions as related to refractories service. RALPH A. SHERMAN, W. E. RICE, AND L. B. BERGER. *Mech. Eng.*, **48** [12], 1389 (1926). —The experimental analysis of the factors governing the life of refractories in a large boiler-furnace are discussed. The furnace conditions which were considered significant and which are being investigated are: (1) the temperature and rate of change of temperature of the refractory; (2) the furnace-gas temperature; (3) the furnace-gas composition including SO_2 and SO_3 content; (4) the velocity of furnace gases; (5) the chemical and mineralogical composition and the quantity of the slag carried in the

gases. Many tables, curves, and photographs give the following conclusions: 1. The temperatures of the surface of the refractory ranged from 2100 to 2500°F. They were not apparently lower on the surface of the ventilated blocks than of the solid bricks, except when caused by slag accumulation, but the gradient was much steeper and less of the wall was at a high temperature. The lowest temperatures measured were in the bridgewall and the highest on the front wall. 2. The survey of gas temperature and composition showed great stratification in the furnace, with high temperatures and deficiency of air at the front wall and middle of furnace, and low temperatures and high excess of air at the bridgewall. The ventilated blocks furnished sufficient air at the front wall but had little effect in the middle of the furnace, except at the wall surface. 3. The high inclined side-wall tuyeres which had the same area of air openings as the horizontal tuyeres which they replaced did not increase the excess air above the fuel bed but the low inclined tuyeres which had air openings 50% greater in area apparently increased the excess air at the side wall. It is probable that the greatest value of these tuyeres in protecting the wall lies in the fact that they reduce the refractory area exposed to slag action. 4. Neither the side-wall tuyeres nor the ventilated blocks admitted so much air as to materially affect the excess air in the last pass. 5. The composition of the slag samples taken from the furnace walls showed coincidence of high ferrous oxide with zones of high temperature and low excess air. There was no apparent relation between the ferric-ferrous oxide ratio and the softening temperature of the slags. 6. Limited observation of the action of the slag on the walls indicated that the erosion and adhesion were less severe with the ventilated blocks than with the solid walls. C.J.H.

Status of heat-transmission data and knowledge in the refractory field. P. NICHOLLS. *Mech. Eng.*, **48** [11a], 1307 (1926).—The field of heat-transmission in non-metallic materials in excess of 1000°F is discussed. The endeavor to use higher steam pressures and increased production tends to increase the demand for better refractories. Three classes of refractories are discussed: (*a*) materials used for heat insulation, (*b*) true refractories subjected to furnace conditions at temperatures of from 850° to 1650°C, (*c*) materials through which heat transference flows, such as muffles. A bibliography of a number of articles on thermal conductivities together with brief comments as to their values is given. C.J.H.

The open hearth process. H. M. BOYLSTON. *Fuels and Fur.*, **4** [12], 1423–32 (1926). —B. gives the essential of the modern open-hearth process and then gives a description of a typical furnace. Ceramic materials are used for the bottom, back-wall roof and in the regenerators. In a discussion of the acid open hearth process, the modern methods used in making up the bottom are described, as well as the operations of charging, melting, purification, conditioning, and tapping. The basic process is described in the same way. New processes and recent improvements in design are then discussed. A.E.R.W.

Various uses of vitreous silica and vitreous quartz. W. W. WINSHIP. *Fuels and Fur.*, **4** [12], 1485 (1926).—A description of the properties of vitreous silica of different kinds and of its application in different industries. A new product of fused silica grains, bonded with gelatinous silica, promises possible usefulness in various fields. This product can be readily molded, does not require treatment at high temperatures and retains the low coefficient of expansion characteristic of fused silica. A.E.R.W.

Liners for steel ladle bowls. ANON. *Fuels and Fur.*, **4** [12], 1503 (1926).—A description of ladle liners made of high grade clay. They are made in 4 parts and can be assembled with practically no labor. A long life is claimed. A.E.R.W.

Bureau of Standards examines refractory oxides. ANON. *Ceram. Ind.*, **7** [6], 660 (1926).—An investigation of refractories suitable for melting pure iron and pure

nickel in Arsem furnaces. The most suitable refractory was found to be C.P. grade magnesia calcined at 1600°C and bonded with alcohol and shellac or a solution of magnesium chloride. For melting pure platinum and platinum-rhodium alloys in high frequency induction furnaces, commercially sintered zirconia was found satisfactory. This material is purified by acid washing to remove iron and by roasting to remove carbides and carbon, and is then prepared as a slip for casting crucibles in plaster molds.

F.P.H.

Secure apparatus to measure properties of clays. ANON. *Brick Clay Rec.*, **69** [12], 902 (1926).—A description of apparatus used in tests carried out on sagger clays at the Bureau of Standards. Seventeen sagger clays have been tested for moduli of elasticity and rupture at both room temperature and at the temperature at which saggers made from these clays failed in an air-quenching test. The data indicate that 13 clays have greater transverse strength and 4 clays have less strength at the higher temperatures. A wide variation was found to exist in the moduli of elasticity, ranging from a minimum of 706,000 lbs./in.^{2} to a maximum of 8,040,000 lbs./in.^{2} All but 2 clays showed a greater modulus at the higher temperatures used than at room temperature.

F.P.H.

Refractory materials in carbonization plants. ANON. *Chem. and Ind.*, **45**, 857 (1926).—The Fuel Department of the Manchester College of Technology presented an exhibit at the National Coal Products Exhibition, showing test pieces which had been taken at various stages of tests on refractories as used in construction. Micro-and macro-sections of silica brick, and the degree of conversion of silica into stable forms, were demonstrated.

H.H.S.

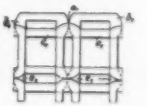
Refractories for melting pure metals: iron, nickel, platinum. L. JORDAN, A. A. PETERSON, AND L. H. PHELPS. *Trans. Amer. Electrochem. Soc.*, **50**, 115–24 (1926).—Crucibles made from commercial fused oxides, alumina, zirconia, and magnesia, were unsuitable for melting pure iron, the alumina and zirconia because of contamination of the melt by silicon and the magnesia because of sulphur. Strong and dense crucibles can be made from calcined, chemically pure magnesia mixed with 2% of magnesium chloride and about 10% of water, and such crucibles fired to about 1600° enable pure melts to be obtained. Magnesia crucibles bonded with shellac and alcohol are also satisfactory, and materials found suitable for melting pure iron were satisfactory also for nickel. Crucibles made of zirconia freed from carbon and iron soluble in acid proved suitable for melting pure platinum and platinum-rhodium alloys, providing the melting is done under oxidizing conditions. Electrically sintered zirconia is extracted with hydrochloric acid (1 : 1), roasted, and prepared as a casting slip by grinding with about 4% of kaolin. Crucibles are then cast, dried, and fired carefully to 1700°. Although hard and strong, zirconia crucibles do not withstand sudden temperature changes, and are best used with an outer supporting crucible of alundum or porcelain.

(*Brit.C.A.*)

PATENTS

Method of making zirconium compounds. C. J. KINZIE. U. S. 1,609,826, Dec. 7, 1926. The method of treating zirconium ores, which comprises mixing the ores with an alkali and heating the charge without fusion but with decomposition of said material resulting in a zirconium compound soluble in dilute acids.

Checkerwork brick. HERMANN MOLL. U. S. 1,610,575, Dec. 14, 1926. A heat recuperative checker work comprising horizontal courses of hollow bricks, alternate courses crossing one another, each brick having a continuous longitudinal passage therethrough, the ends of



bricks, of each course arranged in contact throughout their length, whereby the overlapping ends of the bricks in the courses form a continuous column.

Fused quartz product and process of producing same. ELIHU THOMSON. U. S. 1,610,182, Dec. 7, 1926. The method of fabricating articles having substantially the properties of fused or vitreous quartz which consists in converting by fusion to a vitreous state crystalline silica, mixing a small proportion of a more fusible vitreous material therewith, molding the mixture, and finally heating to a temperature sufficiently high to soften the binder but insufficient to fuse the silica.

Manufacture of refractory bricks. PFÄLZISCHE CHAMOTTE U. THONWERKE (SCHIFFER & KIRCHER) A.-G. Eng. Pat. 248,369, Feb. 2, 1926. The refractory clay is worked up without the addition of grog, and with a moisture content not exceeding 20% by weight. It is disintegrated without previous drying or heating or subsequent moistening to a grain size varying from a fine powder to 10 mm. The material is then intimately mixed, molded under pressure, and fired in the usual way. (*Brit.C.A.*)

Terra Cotta

The manufacture of spiral acid rings. B. MIFFLIN HOOD. *Bull. Amer. Ceram. Soc.*, **5** [12], 472–73 (1926).—The development of a machine to produce spiral acid rings is discussed. These rings consist of a cylinder of clay made with a spiral or helical plane in the inside. A double shafted auger machine having a solid shaft revolving at a high rate of speed and forming the spiral while auger blades on a slower moving hollow shaft formed the cylinder was perfected. Statistics as to the production of these rings are given. E.J.V.

Rubber terra cotta blocks laid in London. ANON. *Brick Clay Rec.*, **69** [12], 909 (1926).—An experiment in the use of rubber-capped terra cotta paving blocks is being made in an important London thoroughfare, New Bridge Street. Heavy terra cotta blocks, 10½ inches by 8 inches, are laid as a base to hold a superimposed rubber cap, ⅜ of an inch in thickness. The blocks with these rubber caps are laid on a 12-inch concrete bed, with a cushion of sand ¾ of an inch thick. They are being set in by means of joints, composed of a special bitumen and rubber mixture. They are known as Gaisman blocks. F.P.H.

White Wares

A modern frit furnace. W. C. STIEF AND S. E. HEMSTEGER. *Bull. Amer. Ceram. Soc.*, **5** [12], 473–76 (1926).—A rotary smelting furnace of 1200-pound capacity, heated with oil, and equipment required to operate it are described. The operation and method of smelting are discussed in detail. The cost of producing frit by this method is very low in comparison to the old sagger method and the frit has the outstanding qualities of (1) uniformity of composition and (2) being capable of grinding easily. E.J.V.

Notes on feldspar tests. W. L. SAMPLE. *Bull. Amer. Ceram. Soc.*, **5** [12], 477 (1926). —Methods of making fusion tests of feldspars are briefly discussed, with particular stress on the shape of the test piece and the bond used. E.J.V.

Cements for glass and pottery. M. DE KEGHEL. *Pottery Gaz.*, **51** [593], 1742 (1926); *Amer. Glass Rev.*, **46** [9], 20 (1926).—Recipes for glues and cements of various types to use on glass, porcelain, earthenware, etc. are given. E.J.V.

A Czechoslovakian tile plant. MALCOLM B. CATLIN. *Ceramist*, **8** [8], 504–507 (1926).—The tile plant of the Rakonitzer and Unter-Themenauer Keramika Werke, at which 25% of the tile for the Holland tunnel was produced, is described. Seventy per cent of the annual output of 5 million sq. ft. is exported. The wages of the 800 employees are given. They are extremely low when expressed in dollars. The factory

maintains living quarters, the labor is quite dependent and the turnover small. Excellent raw materials are close at hand. The plant has grown from a much smaller one in an unsystematic way. Floor and wall tile are manufactured by methods similar to those used in America. Some extremely thin tile ($\frac{5}{16}$ inch) are made for export. The methods of pressing and kiln equipment are described. A new 320-foot tunnel glost kiln fired with producer gas is being installed. Automatic machinery, particularly of American manufacture, is being used more frequently. The technical control is improving, although still inferior to that in American plants. Their products are featured by a wide variety of color and a large output of porcelain stoves which are used extensively in that country. A.E.R.W.

Suggestions regarding use of sodium silicate in casting clay ware. S. J. McDowell. *Ceram. Ind.*, **7** [6], 661 (1926).—The term water-glass or sodium silicate includes a range of liquids which vary in their ratio of soda to silica from 2 : 3 to 1 : 4 and may vary in amount of water present from 45 to 70% or even higher. The high silica sodium silicates are more efficient in decreasing the flowability of casting slips than the high soda sodium silicates based on the % of Na_2O added to slips. On the same basis sodium hydroxide and sodium carbonate are not as efficient as the silicates. For the 6 clays investigated it is estimated that about 80% high silica silicate and 20% (by weight) soda ash should give the best mixture for the electrolyte used in casting. F.P.H.

Porcelain or faience. H. Hermann. *Keram. Rund.*, **34**, 400–401 (1926).—The boundary between porcelain and faience is not always clearly defined and since faience is often similar to porcelain it should in some cases be called porcelain. H.G.S.

The constitution of porcelain during firing. Lyssin. *Keramika i Steklo*, **10**, (1925); *Keramos*, **5**, 417 (1926).—The firing of porcelain is governed by the physical chemical reactions taking place during firing. The importance of maintaining oxidizing, reducing, and neutral kiln atmosphere during different stages of firing is emphasized. H.G.S.

Pottery. Walcot Gibson. *Brit. Geol. Surv. Mem.* (1925).—Geology of the country around Stoke-on-Trent. The manufacture of pottery has from an early period constituted the staple industry. It is found that the chief towns are situated, and extend in an almost continuous line, along the outcrop of the clays and marls once used in the manufacture of common earthenware and still needed on an extensive scale in the construction of the containing vessels ("saggers") in which the potter places his wares in kilns. Cheaply got, long-flaming coals, occurring in intimate association with the clays, have also been a contributing factor. O.P.R.O.

PATENTS

Pottery-molding machine. Andrew Baird. U. S. 1,608,921, Nov. 30, 1926. In a molding machine, the combination of a rotary mold supporting plate, a former vertically movable toward and away from the plate, means for intermittently rotating the plate while the former is being moved away from the plate, including a mold shaft to which the plate is secured, a ratchet wheel fixed on the shaft, a pawl contacting the ratchet wheel, means for moving the pawl tangentially of the ratchet wheel, including a rock shaft having a pair of arms thereon, a link connecting one of the arms with the pawl, a link connecting the other of the arms with a vertically movable traveler, and means for lifting the traveler simultaneously with the upward movement of the former.

Process of assembling insulator parts. A. O. Austin. U. S. 1,609,598, Dec. 7, 1926. The process of joining parts of insulators or similar articles, wherein a surface of one of the parts is roughened and coated with a fusible or volatile substance, the process comprising the steps of connecting the surface by means of cement to another part and submerging the joint thus formed in water to prevent entry of the coating material into the cement during setting of the cement.

Equipment and Apparatus

Several gas expansion porosimeters. A. ERNEST MACGEE. *Jour. Amer. Ceram. Soc.*, **9** [12], 814–22 (1926).—A relatively inexpensive and simple brick porosimeter and its operation is described. A convenient indirect and a direct reading porosimeter for small test pieces is described. The direct reading porosimeter reduces calculations to the minimum.

Rubber, an effective material to resist corrosion and abrasion. B. W. ROGERS AND H. E. FRITZ. *Bull. Amer. Ceram. Soc.*, **5** [12], 467–72 (1926).—Data and illustrations of use of rubber as a corrosion-resisting and abrasion-resisting material in chemical and allied industries are presented. The Vulcalock process, whereby soft rubber may be attached to metal, is discussed. Results of work in developing a commercial rubber lining for ball mills are set forth and phases of industries in which it is being adopted are enumerated. E.J.V.

The "how and why" of pyrometer resistance. ANON. *Amer. Glass Rev.*, **46** [9], 15 (1926). (Reprinted from *Glass.*)—A clear explanation showing how robust, yet accurate, pyrometers of low resistance, may be applied in many places in glass works. A partly mathematical discussion of the use of pyrometers. E.J.V.

Methods that have been and are being used for measuring heat transmission. F. G. HECHLER. *Mech. Eng.*, **48** [11a], 1337 (1926).—The article has to do with methods of measuring thermal properties of insulating materials particularly for buildings. Investigators have used different methods which are difficult to correlate. H. divides the different methods into 6 classes and discusses each: (1) ice box, (2) oil box, (3) cold air box, (4) hot air box, (5) guarded hot air box, (6) steam or condensation. A bibliography of recent work is given together with a discussion of each investigation. C.J.H.

The insulation of electrically heated equipment. E. A. PHOENIX. *Fuels and Fur.*, **4** [12], 1465–68 (1926).—Efficient insulation is absolutely necessary to operate electrical heating equipment economically. P. shows how Darling's curve can be used in determining the B.t.u. losses of furnaces which are in operation. A simple formula for determining the approximate heat losses for a proposed wall construction is given and its use illustrated. Four diagrams showing temperature gradients and heat losses through different wall constructions, based on actual tests, are shown and the insulation of ovens discussed. Where oven walls are air tight, powdered insulation will give the best results at the lowest cost, otherwise brick or block form should be used. A.E.R.W.

Take the work to the man and not the man to the work. ANON. *Ceram. Ind.*, **7** [6], 629–51 (1926).—A discussion of material-handling equipment used in the ceramic plants. Flow sheets show the successive operations in the production of enamelware, pottery, and glass, and the handling equipment needed to perform these operations with the greatest facility and economy. The different types of handling equipment are illustrated with numerous pictures. F.P.H.

Elutriation. L. ANDREWS. *Engineering*, **122**, 225 (1926).—A system known as "Kinetic elutriation" for rapidly and continuously classifying fine materials by hydraulic means. H.H.S.

Drying machines for industrial processes. ANON. *Engineering*, **122**, 659–62 (1926).—Describes and illustrates the Turblex and Turbo-Simplex machines made by Tomlinsons of Rochdale. H.H.S.

Fluid heat transmission for high temperatures in industrial processes. J. A. REAVELL. *Chem. and Ind.*, **45T**, 367–76 (1926).—R. distinguishes between heat

transmission and heat transference, and discusses the former, chiefly, as neither water nor molten lead is suitable as transmission medium, with regard to oil circulation heating systems. H.H.S.

Ruths' steam accumulators. ANON. *Chem. and Ind.*, **45**, 851–55 (1926).—Describes the accumulator with 5 photographs and diagrams, and states that 283 installations have been made in 21 countries (4 in U. S.). H.H.S.

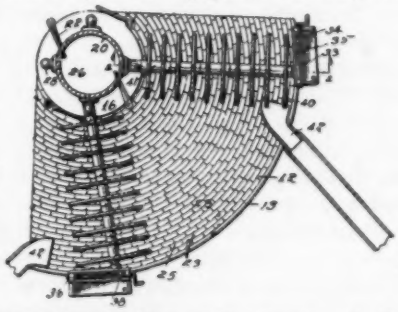
Synthetic fuel. A. W. NASH. *Chem. and Ind.*, **45**, 876–78 (1926).—A review of the patent literature of European countries on the catalyzed interaction of CO and H, beginning with the Badische patent of 1913. H.H.S.

Temperature control in works processes. W. WOODHOUSE. *Chem. and Ind.*, **45**, 880 (1926).—Above 1400°C, the only available type of instrument for measuring temperature is the optical pyrometer. It is not so satisfactory as types suitable for lower temperatures, because the personal element enters into its use. The Cambridge disappearing filament pyrometer is not so influenced by the personal element. The Foster fixed-focus radiation pyrometer is a practical instrument. Optical pyrometers are very useful for controlling processes where a definite temperature corresponding with some point in the manufacture of the article is required, such as the temperature of the molten metal used for making spun pipes. Below 1400°C, thermocouples (Pt–Rh) are used in conjunction with thread-recorders, and base metal (ironconstantan) couples or mercury in steel thermometers at lower temperatures. H.H.S.

PATENTS

Car-transfer apparatus. J. H. FOX AND A. E. EVANS. U. S. 1,610,366, Dec. 14, 1926. The combination with a plurality of parallel tracks adapted to carry a series of cars or tables, a transfer track extending transversely of the tracks at one end thereof, a transfer car mounted on the track provided with a track adapted to receive a car from any one of the parallel tracks when the track on the transfer car is brought into alignment with such one of the parallel tracks, an indexing cam extending transversely of the parallel tracks provided with a recess for each of the tracks, a spring pressed indexing member carried by the transfer car and adapted to engage the recesses, and power means carried by the transfer car for retracting the member against the pressure of the spring.

Pug mill. H. R. STRAIGHT. U. S. 1,611,389, Dec. 21, 1926. A pug mill comprising an annular pan, a hopper for feeding material to the central portion of the pan, a radially arranged shaft having one end pivotally connected near said hopper adapted to swing in a substantially horizontal plane, and a series of muller wheels for the shaft.



Process of and apparatus for treating minerals. MCKINLEY STOCKTON. U. S. 1,611,791, Dec. 21, 1926. In a milling and drying process, the prevention of dust loss by disintegrating material containing moisture, passing such disintegrated material by pneumatic means into a separating apparatus, discharging the substantially dust-free air from such separating apparatus, discharging the disintegrated material from the separating apparatus into a heated gas, passing such gas and disintegrated material into a second separating apparatus and circulating the partly spent gas containing dust from the second separating apparatus to the moist disintegrated material.

Kilns, Furnaces, Fuels, and Combustion

Fuel oil in the British pottery industry. ANON. *Ceramist*, **8** [8], 535–37 (1926).—An abstract of data given in "Commerce Reports" published by the Bureau of Foreign and Domestic Commerce and pertaining to the use of oil as fuel in the British pottery industry is given. The use of oil was initiated as a consequence of the coal strike. The present consumption is not large but the possibilities are interesting. The advantages of oil firing and the difficulties to be overcome in its introduction are discussed. As a result of the strike pottery exports have been retarded and imports increased. A comparison of the cost of drying silica brick with coal and with oil is given. A.E.R.W.

Brown coal briquettes for firing. F. ROHRWASSER. *Sprechsaal*, **59**, 509–10 (1926).—A bibliography of the development of briquette firing. H.G.S.

Brown coal briquettes for firing. J. DORFNER. *Sprechsaal*, **59**, 541 (1926).—D. discusses the application of brown coal briquette firing in practice. H.G.S.

The artificial drying of brick. K. CEBULLA. *Tonind. Ztg.*, **50**, 439–41 (1926).—It is of great importance to introduce hot air with a high humidity during the early stages of drying. By so doing the ware becomes thoroughly warmed throughout before drying commences and thereby cracking is reduced. H.G.S.

A new method of firing. HIELSCHER. *Tonind. Ztg.*, **50**, 470–71 (1926).—The A. Vobach method of firing is described. In the method the heating flues do not pass at right angles to the firing chamber but pass up obliquely on either side of the same. H.G.S.

A new method of firing. W. WITTE. *Tonind. Ztg.*, **50**, 781–82 (1926).—W. discusses the method described by Hielscher (*Tonind. Ztg.* **50**, 470–71 (1926)) and questions the utility of this method of firing. H.G.S.

A new method of firing. W. PERPÉET. *Tonind. Ztg.*, **50**, 782 (1926).—P. discusses the method described by Hielscher (*Tonind. Ztg.*, **50**, 470–71 (1926)) and describes a method superior to this. H.G.S.

The Ceramic Society. ANON. *Pottery Gaz.*, **51** [593], 1707–1708 (1926).—An abstract of a paper "The Ignition of Gases" by H. B. Dixon of Manchester University, read before the English Ceramic Society at Stoke-on-Trent, and discussion thereof, are given. E.J.V.

National coal products, chemical and engineering exhibition. ANON. *Chem. and Ind.* **45**, 849, 850, 856–861, and **45T**, 385–424 (1926).—The exhibition which was held at Manchester, Eng., Nov. 16–27 is described. Every aspect of mining and of coal and coke, tar and tar products industries was presented, together with the refractory materials used in carbonization plants, and the testing, analytical, and research work connected therewith. H.H.S.

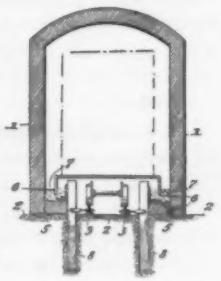
Gaseous fuel. W. B. DAVIDSON. (Meeting, Nov. 9, Soc. Chem. Ind.) *Chem. and Ind.*, **45**, 862 (1926).—Gas fires were introduced in England in 1840. The purity of gas has received attention since 1860, when the amount of H_2S and NH_3 were restricted by law. The 1920 Gas Act is reviewed with special reference to the introduction of the "therm" and the methods of assessing charges. Gas is cheaper for heating than electricity, and there is only 2% leakage in transport through mains; D. suggests that gas should be compulsorily stripped for benzene, etc. H.H.S.

BOOK

Spontaneous combustion of coal. W. FRANCIS AND R. V. WHEELER. Safety in Mines Res. Board Paper, No. 28. London: H. M. Stationery Office, 1926. Price 1s 6*d*. H.H.S.

PATENTS

Drier kiln. H. R. STRAIGHT. U. S. 1,610,630, Dec. 14, 1926. A drier comprising a series of longitudinally extending and parallel passages, means for moving ware horizontally and longitudinally through said passages, each of the longitudinal passages being divided into a series of chambers, and means for circulating a drying medium in a continuous manner and successively through each of the chambers and in a downward movement through the ware.



Holder and brace for the rails and sand seals of tunnel kilns. R. W. SCHWEIKER. U. S. 1,611,566, Dec. 21, 1926. In a holder and brace for the rail of a tunnel kiln, the combination with an upright channel iron having its lower part anchored, of a bolt extending through the webs or walls of the channel iron, and an adjustable connection between the bolt and the rail.

Muffle kilns [for ceramics etc.]. S. CROSBIE AND C. H. F. COLLARD. Eng. Pat. 253,959, Sept. 21, 1925. An "endless" series of separate, continuous muffle kilns connected by flues is arranged polygonally around a central space. Each muffle in turn becomes partly heated by waste gases from the kiln immediately preceding it. A combustion chamber below the floor of each kiln is connected with a number of flues formed in the surrounding kiln walls and with a single crown flue leading to down flues in the walls. (*Brit.C.A.*)

[Tunnel] kilns or ovens for baking pottery etc. R. M. D'ARLEUX AND E. VIOLETTE. Eng. Pat. 254,023, Mar. 28, 1925. A mixture of gaseous fuel and air is introduced into the tunnel through tuyères constructed with a thermosiphonic circulatory cooling system. The size and number of the tuyères, the pressure of the gaseous fuel, and the capacity of the hearth are so adjusted that the pressure in the kiln is greater than atmospheric. Sloping baffles are fitted at the mouths of the tuyères to spread the flames. (*Brit.C.A.*)

[Brick or pottery] kilns. G. V. EVERS. Eng. Pat. 254,438, Apr. 24, 1925. In a multi-chamber kiln, fire boxes are provided at each of the 4 corners of each chamber except the end chambers, in which the furnaces are arranged in the end walls. A low baffle wall is built near the inner end of each furnace to give a short vertical passage for the hot gases. Passages are provided at the base of the partitions between the chambers to give inter-communication. A central outlet in the floor of each chamber leads to the chimney flue. (*Brit.C.A.*)

[Down-draft] kilns for the manufacture of bricks and pipes. E. EVANS. Eng Pat. 255,188, May 18, 1925. The hot gases are drawn through the perforated floor of the kiln chamber and pass through hooded pipes covering holes in an intermediate floor spaced from the kiln base. The holes near the peripheral wall in the intermediate floor are of larger cross-section than those near the center. A portion of the gases passes from the space beneath the intermediate floor direct to the chimney, the remainder being drawn through closed passages beneath the kiln base, which communicate directly with the space beneath the larger apertures in the second floor. (*Brit.C.A.*)

[Kilns and other heat treatment furnaces. MORGAN CRUCIBLE CO. AND C. W. SPEIRS. Eng. Pat. 257,472, Dec. 18, 1925. Electrically heated tunnel kilns are provided with trucks for supporting the ware, furnished with tables arranged to rotate as the truck is traversed through the kiln, whereby the articles are subjected to an approximately uniform heat treatment. (*Brit.C.A.*)

Oil- or gas-fired [pottery] kilns. W. S. MURRAY. Eng. Pat. 258,318, June 4, 1925. In kilns used for firing pottery, a heat economy is effected by having the kilns arranged in tandem or series each communicating with the next by a passage at the bottom, and the last leading into a shaft. Burners are so arranged inside each kiln that the products of combustion, after heating the first kiln, pass on to the next, which thus becomes partly warmed. (*Brit.C.A.*)

Geology

New china clay plant in North Carolina. ANON. *Ceramist*, **8** [8], 500–507 (1926).—The recent developments in the china clay and feldspar industries of North Carolina are discussed. The new plant of the Pollard Clay Co., at Burnsville, which went into full operation on Aug. 1, is described. Several new washing methods are used which increase the output and simplify the elimination of mica and other operations. The most interesting features of the process are described and the properties and chemical composition of the washed clay, which is of exceptionally high quality, are given. A.E.R.W.

North Carolina feldspar. V. D. KELSEY. *Ceramist*, **8** [8], 524–27 (1926).—The fact that during the past 2 years half the feldspar consumed in America was produced in North Carolina shows that the feldspars from the South are playing no small part in the present industrial expansion. Although the beginning of the industry a few years ago was not altogether auspicious, the mining operations today compare favorably with the most up-to-date in this country. A.E.R.W.

Texture of ceramic materials. J. F. MCMAHON. Can. Dept. of Mines, Mines Branch. *Invests. of Ceram. Mats.*, 1926.—The most salient points regarding texture, including shape of grains, size, texture and plasticity, drying, shrinkage, firing and grinding are touched upon. Emphasis is given to the manner in which texture affects the various working problems of importance in the clay industry. The following table gives a general summing up:

	Fine	Coarse	Round	Angular	Proper grading
Plasticity	Advantageous	Disadvantageous	Dis.	Ad.	Ad.
Drying	Disadvantageous	Advantageous	Ad.	Dis.	"
Firing: water-smoking	"	"	"	"	"
Firing: oxidation	"	"	"	"	"
Firing: vitrification	Advantageous	Disadvantageous	Dis.	Ad.	"
Dry strength	"	"	"	"	"
Spalling	Disadvantageous	Advantageous	Ad	Dis.	"
Abrasion	Advantageous	Disadvantageous	Dis.	Ad.	"
Efflorescence and corrosion	"	"	"	"	"
Mill additions for color	"	"	"	"	

O.P.R.O.

Clays. H. RAGGATT. *Indus. Australian and Min. Stand.*, **76**, 343 (1926).—The origin, distribution, and industrial uses of the clays of New South Wales are given: (*a*) ceramic clays—whiteware clays; stoneware and terra cotta clays, (*b*) white "filler" clays, (*c*) fire clays, (*d*) brick clays, roofing tile, and common earthenware clays, pipe clays, (*e*) Portland cement clays are discussed. Ceramic technology is not sufficiently advanced to enable these groups to be very sharply differentiated, but it is known that ceramic clays of certain types are widely distributed in New South Wales. The value of clays produced during 1925 was more than 1½ million dollars. The clay industry appears to be well established in a large number of its branches, and as the State's clay resources are more fully exploited and understood, the industry cannot but grow as the population increases, causing an augmented demand for products in which clay is an important ingredient. O.P.R.O.

Colloidal properties of clays. R. C. WALLACE. *Trans. Roy. Soc. Can.*, **17** [Sec. 4], 69–77 (1923).—Distribution of the colloidal products of rock weathering. While the colloidal properties of clays have been the subject of much literature, no evidence has come to the attention of W. to show gradual increase in colloidal content from bottom to top of the seasonal layers in freshwater precipitation, nor of a more widespread lateral extension of colloidal sediments into deep parts of a fresh water basin than in the oceans. Such a vertical sifting in the inshore zone and lateral continuity of the colloidal material, should characterize freshwater as distinguished from marine sedimentation. It has been argued that a certain degree of salinity must be postulated in the earlier seas in order to flocculate the suspensoids and give rise to the sediments as they now appear in shales. This condition seems hardly necessary unless where a distinctive type of sedimentation peculiar to marine conditions has been recognized in the field; for lakes are today being silted up, and lakes have been silted up through geological ages, without the assistance of electrolytes, and sedimentation might have occurred in similar fashion in the great oceanic basins of early geological time. O.P.R.O.

BOOK

Location of mineral fields: Modern procedure in the investigation of mineral areas and the subsequent verification of extent. M. H. HADDOCK. London: Crosby, Lockwood & Son, 1926. Price 9*s*, 6*d*. H.H.S.

Chemistry and Physics

The catalytic oxidation of CO in contact with quartz glass. A. F. BENTON AND T. L. WILLIAMS. *Jour. Phys. Chem.*, **30** [11], 1487–96 (1926).—B. and W. did not check the work of Bodenstein and Ohlmer in their study of the kinetics of the oxidation of CO to CO_2 with quartz glass as catalyst. The work of Bodenstein and Ohlmer indicated that an excess of CO decreases the reaction velocity. Langmuir accounted for this by postulating that the large area of quartz glass surface became covered with adsorbed CO. B. and W. found the extent of such adsorption to be very small and re-determined the kinetics of the reaction using an even more extensive quartz surface than had ever been previously used. Their reaction velocity obtained at 500°C is less than that of Bodenstein and Ohlmer obtained at 300°C. They attributed difference in latter case to presence of small amounts of impurities in the catalyst. They show that the reaction rate, $R = P \cdot K_{co}^{\frac{1}{4}}$. L.A.P.

Standardized definitions of pyrometric terms issued. ANON. *Brick Clay Rec.*, **69** [12], 895 (1926).—Pyrometric terms are defined by the industrial group of the Association of Scientific Apparatus Makers. Among these terms are thermometer, pyrometer, resistance thermometer, radiation and optical pyrometers, thermocouple, thermoelectric pyrometers, hot junction, cold junction, extension leads, accuracy, and sensitivity. F.P.H.

X-ray diffraction measurements upon compounds in the system soda-lime-silica. RALPH W. G. WYCKOFF AND GEORGE W. MOREY. *Am. Jour. Sci.*, **12** [71], 419–40 (1926).—The diffraction data have been limited to powder measurements as it has not been possible to grow single crystals of any of these compounds of a size sufficient for Laue or spectrum photographs. Powder diffractions measurements have been recorded for the compounds: $Na_2Ca\ SiO_4$, $Na_4Ca\ (SiO_3)_3$, $Na_2Ca_2(SiO_3)_3$. Except for differences in faint lines the data from the first 2 of these crystals are practically indistinguishable. The problems of interpretation presented by these first 2 compounds are thus similar to those introduced by mullite and sillimanite in that 2 compounds of different chemical composition give rise to nearly identical X-ray diffraction effects. The compound $Na_2Ca\ SiO_4$ has cubic symmetry. The unit cube contains 4 molecules and has a length

of edge $a_0 = 7.49$Å. The metal atoms have approximately the positions: 4b, 4c, 4d, 4e. The positions of the oxygen atoms cannot be established. Crystals of $Na_4Ca(SiO_3)_3$ exhibit forms which are apparently cubic. Their powder diffraction pattern nevertheless exhibits a few lines which cannot be ascribed to a crystal having cubic symmetry. Hence it is probable that the symmetry of this substance is pseudo-cubic. The diffraction lines which can belong to a cubic crystal fit a cube having $a_0 = 7.547$Å and containing 2 molecules of $Na_4Ca(SiO_3)_3$. F.P.H.

To determine the so-called power of crystallization. C. CORRENS. *Sitzungsbericht Preusz. Akad. Wiss. Berlin* (Phys.-mathem. Kl.): *Keramos*, **5**, 421 (1926).—The power of crystallization of alum was investigated. A saturated solution of $Al_2(SO_4)_3$ was placed between glass and muscovite plates. In the case where glass plates were used the crystallization was retarded by placing weights upon the same but this did not seem to change the same where weights are placed on muscovite plates. H.G.S.

The solid solutions of calcium and sodium bisilicates. A. GINSBERG AND C. NIKOYCSIEN. *Nachr. geochem. Sektion d. Ver. d. Metall. u. Chem.*, 35–38 (1926); *Keramos*, **5**, 421 (1926).—The system Na_2SiO_3 (1093°C) and $CaSiO_3$ (1512°C) was investigated. It showed a maximum corresponding to the mixture $2Na_2SiO_3 \cdot 3CaSiO_3$ which had a melting point of 1255°C and two minimums were obtained at 1042° and 1230°C. H.G.S.

A microscopic study of the transition of cristobalite from its alpha to beta form. R. WEIL. *Compt. rend.*, **180**, 1949–51 (1925); *Keramos*, **5**, 421 (1926).—The transition of cristobalite from the alpha to the beta form was investigated with a polarizing microscope with natural cristobalite from various sources. It was found that the beginning of the transition took place between 175 and 195°C while the end occurred between 205 and 230°C depending upon the cristobalite used. In one case one transition took place between 175 and 190°C and a second transition took place between 217 and 245°C. H.G.S.

The physical properties of ceramic bodies. FELIX SINGER. Reprint from *Zeit. Elektrochem.*, pp. 382–85 (1926).—Tables setting forth physical properties of ceramic materials are given and various properties are discussed. The newer material is included in the following tables:

TABLE I

THE PHYSICAL PROPERTIES OF REFRACTORY PRODUCTS AND FIRECLAY BODIES

No.	Body Refractory products	Sp. gr.	Bulk sp. gr.	Pore space %	Porosity by water absorption %
1	Chamotte (grog) body XX				
2	Chamotte pot body				
3	Special body Z.128	2.765	1.962	29.1	10.8
4	Z. 487 magnesite	3.44–3.60	2.663	24–30	
5	Carbon brick	about 3		about 40	
6	Normal chamotte brick	2.5–2.7	1.9	15–35	
7	Special body Z. 235	2.655	2.021	23.9	10.4
8	Quartzite (Quarzgut)	2.20–2.07	2.068	6.0	
9	Silit	2.67–2.83	2.2	17.6	
10	Alundum	3.91			
11	Silica brick	2.32–2.5		18–43	
12	Carborundum brick	3.1–3.2		about 30	
13	Chromite brick	about 4		about 10	
14	Marquardt's body				
15	Z. 890				
16	English M. } Fireclay				
17	Lu 1004/9 } Fireclay				
18	Lu 1706 } Fireclay				

TABLE I (*continued*)

No.	Body Refractory products	Sp. gr.	Bulk sp. gr.	Pore space %	Porosity by water absorption %
19	SiO_2 { II axis / I axis }	2.65			
20	Al_2O_3	3.95–4.0			
21	MgO	3.6			
22	CaO	3.493			
23	Cr_2O_3	6.2			

No.	Compressive strength kg/cm²	Tensile strength kg/cm²	Elastic strength kg/cm²	Modulus of elasticity kg/mm²	Torsional strength kg/cm²	Ball compressive strength
1						
2						
3		94			117	
4	1037	122	246	8919		748
5	about 325					
6	70–300					
7		87			157	
8	19800			6970–7260	300	
9			800–1000			
10		120	1085			
11	100					
12						
13						
14						
15	560		90			
16	865		170			
17	1070		191			
18	1230					
19	{ 25000 / 23000 }	{ 1160 / 850 }	{ 1400 / 920 }	6900		
20						
21						
22						
23						

No.	Elastic strength under impact $\frac{cm/kg}{cm^2}$	Loss by abrasion (rattler) wt. loss in %	Hardness: Loss in sandblast loss in cm³	Hardness: Scleroscope	Cone fusion Seger cone	Softening temp. under load °C
1	0.33				33	
2	0.34				33	
3	1.75	13.4	26.5	30	30	
4		13.9	10.3	23–25	>36	about 1400
5					>42	
6					32–35	1300
7	1.7	7.2	5.5	35	28	
8					31–32	
9						
10						
11					33–35	1600–1700
12					>42	>1700
13						about 1300
14					37	
15						
16						
17						
18						
19					{ 1625°	
20					2050°	
21					2800°	
22					2572°	
23					1990°	

TABLE I (*concluded*)

No.	Coeff. of linear expansion	Heat capacity, sp. ht. between 17° and 100° C	Heat conductivity Kcal · m^{-1} · h^{-1} · degrees^{-1}	Thermal conductivity heat conductivity / thickness×sp. heat	Electrical resistivity in megohms (=1000000 ohms)
1		0.205			
2					
3	5.5×10^{-6}				
4		0.253[1]	0.396[2]		<137
5		0.312[1]			
6	$1.6–5.7\times10^{-6}$	0.190	0.432[2]		<137
7	6.7×10^{-6}	0.1850			
8	0.55×10^{-6}	0.2777	0.9360		
9		0.19			
10	7.1×10^{-6}			about 1.44	
11		0.219[1]	0.684[2]		<175
12	4.7×10^{-6}		8.64[3]		<127
13					
14	5.2×10^{-6}	0.229			
15					
16					
17					
18					
19	7.81×10^{-6} / 14.19×10^{-6}	0.1913	9.468 / 5.76		
20		0.1967	0.583[2]		
21	13.10×10^{-6}	0.264	0.522		
22					
23		0.177			

[1] Between 17° and 200° C. [2] At 200° C. [3] Average between 0° and 1000° C.

Table II

THE PHYSICAL PROPERTIES OF FUSED QUARTZ

Body	Sp. gr.	Comp strength kg/cm²	Tensile strength kg/cm²	Elastic strength kg/cm²	Modulus of elasticity kg/mm²	Torsional strength kg/cm²
Fused quartz	2.1	19800	over 700		7200	300

Cone fusion Seger cone	Softening temp. under load C.	Coeff. of linear expansion	Heat capacity sp. ht. between 17 and 100° C	Coeff. of thermal resistance
1700–1800 C.		0.55×10^{-6}	0.18	145.7

Heat conductivity, Kcal · h^{-1} · m^{-1} · degrees^{-1}	Thermal conductivity heat conductivity / thickness×sp. ht.	Surface conductivity	Electrical resistvity in megohms (=1000000 ohms)
1.195	3.161		400

Dielectric constant	Puncture voltage
3.5–3.6	30,000 volts at 1.2 mm thickness

TABLE III

THE PHYSICAL PROPERTIES OF STONEWARE

No.	Body	Sp. gr.	Bulk sp. gr.	Pore space %	Porosity by water absorption. %
	Stoneware				
1	Stoneware Z 48	—	2.192	—	—
2	" Z 58	2.537	2.196	13.5	0.28
3	" Z 59	2.510	2.189	12.8	0.03
4	" Z 60	2.537	2.153	15.2	0.27
5	" Z 61	2.485	2.192	11.8	0.27
6	" Z 64	2.532	2.075	18.1	3.19
7	" Z 65	2.559	2.096	18.1	4.41

TABLE III (*continued*)

No.	Body		Sp. gr.	Bulk sp. gr.	Pore space %	Porosity by water absorption %
8	"	Z 66	2.548	2.092	17.9	5.10
9	"	Z 67	2.599	2.177	16.2	3.11
10	"	Z 85	2.459	2.130	13.4	—
11	"	Z 86	2.444	2.127	13.0	—
12	"	Z 87	2.459	2.260	7.8	—
13	"	Z 118	2.649	2.169	18.2	2.50
14	"	Z 119	2.575	2.254	12.5	0.34
15	"	Z 120	2.479	2.323	6.3	0.26
16	"	Z 121	2.559	2.367	7.5	0.75
17	"	Z 122	2.495	2.364	5.2	1.76
18	"	Z 131	2.516	2.111	16.1	2.0
19	"	Z 132	2.527	2.124	15.9	2.3
20	"	Z 134	2.542	2.164	14.8	1.8
21	"	Z 242	2.495	2.236	10.4	0
22	"	Z 243	2.521	2.063	18.2	0.43
23	"	Z 253	2.500	2.162	13.5	—
24	"	Z 254	2.479	2.171	12.4	—
25	"	Z 430	2.479	2.193	11.5	—
26	"	Z 431	2.495	2.209	11.4	—
27	"	Z 432	2.490	2.193	12.0	—
28	"	Z 433	2.521	2.179	13.6	—
29	"	Z 434	2.537	2.173	14.4	—
30	"	Z 435	2.548	2.128	16.5	—
31	"	Z 505	2.804	2.473	11.8	—
32	"	Z 583	2.439	—	—	—
33	"	Z 584	2.479	—	—	—
	Fine stoneware					
34	Fine stoneware	Z 238	2.532	2.316	8.5	0.13
35	DTS-Sillimanit	Z 54	2.449	2.233	8.9	0
36	"	Z 55	2.454	2.276	7.7	0
37	Fine stoneware	Z 640	—	—	—	—

No.	Compressive strength kg/cm²	Tensile strength kg/cm²	Elastic strength kg/cm²	Modulus of elasticity kg/cm²	Torsional strength kg/mm²	Ball compressive strength
1	—	—	—	—	—	—
2	—	100	416	4455	235	891
3	—	102	395	4416	221	978
4	—	99	404	4328	217	975
5	—	97	262	5372	177	1044
6	3246	63	280	4175	150	—
7	3636	87	246	4339	152	—
8	5356	66	234	4189	130	—
9	—	74	271	4393	141	—
10	—	—	—	—	—	—
11	—	—	—	—	—	—
12	—	—	—	—	—	—
13	—	—	—	—	154	476
14	4666	—	376	5540	230	517
15	5816	—	283	5985	224	791
16	4235	—	297	4800	251	912
17	—	—	402	6850	241	796
18	—	115	289	4276	217	696
19	—	116	286	4437	247	711
20	—	83	339	4895	251	724
21	—	88	—	—	—	—
22	—	88	—	—	—	—
23	—	—	—	—	—	—
24	—	—	—	—	—	—

TABLE III (*continued*)

No.	Compressive strength Kg/cm²	Tensile strength Kg/cm²	Elastic strength Kg/cm²	Modulus of elasticity Kg/mm²	Torsional strength Kg/cm²	Ball compressive strength
25	—	—	—	—	—	—
26	—	—	—	—	—	—
27	—	—	—	—	—	—
28	—	—	—	—	—	—
29	—	—	—	—	—	—
30	—	—	—	—	—	—
31	3951	133	360	6367	—	1253
32	—	—	—	6522	—	—
33	—	—	—	6388	—	—
34	—	—	—	—	226	—
35	—	178	416	5087	323	792
36	5833	163	580	6475	—	982
37	—	—	900	14200	—	—

No.	Elastic strength under impact cm/kg / cm²	Loss by abrasion (rattler) wt. loss in %	Hardness: Loss in sandblast loss in cm³	Hardness: Scleroscope	Cone fusion Seger cone
1	—	—	4.7		
2	1.4	—	4.6	60	26
3	1.3	—	5.2	60	26
4	1.9	—	5.6	57	26
5	1.6	—	5.4	56	29
6	1.26	9.3	9.5	49	19
7	1.4	10.6	9.9	39	19
8	1.3	11.1	9.6	44	20
9	1.4	8.8	7.9	41	19
10	—	—	4.0	—	—
11	—	—	5.8	—	—
12	—	—	3.0	—	—
13	—	7.9	6.7	—	19
14	—	5.6	3.5	—	20
15	1.7	5.6	3.1	—	20
16	—	4.0	3.5	—	27
17	—	5.5	3.0	—	17
18	1.5	5.7	5.3	—	27
19	1.6	6.1	5.2	—	28
20	1.6	3.6	3.2	—	29
21	1.8	6.5	5.5	62	28
22	1.5	6.8	6.3	43	28
23	—	—	4.3	—	—
24	—	—	3.4	—	—
25	1.7	6.5	4.0	—	26
26	1.7	8.3	4.1	—	—
27	1.6	3.6	4.0	—	20–21
28	1.5	5.1	4.4	—	26–27
29	1.5	6.0	4.3	—	27
30	1.4	7.0	5.0	—	28
31	1.6	—	3.5	—	—
32	—	—	—	—	—
33	—	—	—	—	—
34	1.7	4.3	2.4	55	27
35	1.8	5.2	2.5	—	—
36	1.7	—	3.9	64	—
37	2.4	—	—	—	—

TABLE III (*concluded*)

No.	Coeff. of linear expansion	Heat capacity, sp. ht. between 17 and 100°C	Coeff. of thermal resistance	Heat conductivity Kcal. $m^{-1} \cdot h^{-1} \cdot$ degree^{-1}	Thermal conductivity / heat conductivity = thickness × sp. ht.
1	—	—	—	—	—
2	4.5×10^{-6}	0.187	3.9	1.05	2.213
3	4.9×10^{-6}	0.185	3.46	0.90	1.938
4	4.5×10^{-6}	0.186	3.7	0.90	1.909
5	4.3×10^{-6}	0.185	3.12	0.90	1.958
6	—	0.186	—	—	—
7	—	0.185	—	—	—
8	—	0.187	—	—	—
9	—	0.187	—	0.90	—
10	—	—	—	—	—
11	—	—	—	—	—
12	—	—	—	—	—
13	—	0.191	—	0.95	1.884
14	—	0.190	—	1.35	2.760
15	—	0.190	—	1.10	2.337
16	—	0.188	—	1.35	2.806
17	—	0.189	—	1.15	2.439
18	—	—	—	1.10	—
19	—	—	—	1.25	—
20	—	—	—	1.30	—
21	—	0.187	—	—	—
22	4.1×10^{-6}	0.186	—	—	—
23	4.4×10^{-6}	—	—	—	—
24	—	—	—	—	—
25	—	—	—	—	—
26	—	—	—	—	—
27	—	—	—	1.00	—
28	—	—	—	—	—
29	—	—	—	1.25	—
30	—	—	—	1.05	—
31	$5.5–6\times10^{-6}$	0.197	3.83	2.00	—
32	—	—	—	—	—
33	—	—	—	—	—
34	5.7×10^{-6}	—	—	—	—
35	—	—	—	1.25	—
36	4.9×10^{-6}	—	3.86	1.00	—
37	—	—	—	—	—

TABLE IV

THE PHYSICAL PROPERTIES OF PORCELAIN

No.	Body	Sp. gr.	Bulk sp. gr.	Pore %	Porosity by water absorption %
1	Porcelain A	2.464	2.269	7.9	0
2	" B	2.459	2.299	6.5	0
3	" C	2.473	2.345	5.2	0
4	" D	2.440	2.341	4.1	0
5	" E	2.446	2.310	5.6	0
6	" F	2.424	2.317	4.4	0
7	" G	2.449	2.298	6.2	0
8	" H	2.495	2.376	4.8	0
9	" Z 152	—	—	—	0
10	Insulator porcelain G	—	—	—	0
11	Insulator porcelain H	—	—	—	0
12	Tableware porcelain	—	—	—	0
13	Berlin hard porcelain	2.46	2.317	4.4	0
14	Experimental hard porcelain 6292	—	—	—	-
15	Hermsdorf porcelain	2.3–2.5	—	—	0

TABLE IV (*continued*)

No.	Body	Sp. gr.	Bulk sp. gr.	Pore space %	Porsity by water absorption %
16	Laboratory porcelain	—	—	—	0
17	Soft porcelain 6833	—	—	—	–
18	American porcelain	—	—	—	–
19	Chinese porcelain	—	—	—	–

No.	Absorption under pressure	Compressive strength Kg/cm²	Tensile strength Kg/cm²	Elastic strength Kg/cm²	Modulus of elasticity Kg/mm²	Torsional strength Kg/cm²
1	0	—	204	656	—	—
2	0	—	161	688	—	—
3	0	—	231	570	—	—
4	0	—	199	696	—	—
5	0	—	239	777	—	—
6	0	—	320	855	—	—
7	0	—	250	686	—	—
8	0	—	265	690	—	—
9	0	7428	—	—	—	—
10	0	—	—	590	7800	481
11	0	—	261	540	7835	500
12	0	—	—	640	8140	—
13	–	—	320	855	8280	—
14	–	—	—	520	—	—
15	0	up to 5600	up to 360	up to 690	7000–8000	480–600
16	0	—	—	410	8880	500
17	–	—	—	—	6840	—
18	–	2840–4614	106–887?	—	—	—
19	–	—	500	—	6500	—

No.	Ball compressive strength	Elastic strength under impact $\frac{\text{cm/kg}}{\text{cm}^3}$	Hardness: Loss in sandblast Loss in cm³	Hardness: Scleroscope	Hardness: Cone fusion Seger cone	Coeff. of linear expansion
1	674	1.75	—	—	—	about $3–4\times10^{-6}$
2	731	1.77	—	—	—	
1	960	1.80	—	—	—	
4	955	1.83	—	—	—	
5	1384	1.95	—	—	—	
6	1376	1.99	—	—	—	
7	986	1.88	—	—	—	—
8	1015	1.88	—	—	—	—
9	—	—	—	—	—	—
10	—	0.90	2.4	—	—	—
11	—	0.95	3.3	—	—	—
12	—	1.36	—	—	—	—
13	1376	1.99	—	—	30	3.8×10^{-6}
14	—	0.08	—	—	—	—
15	—	1.9	—	—	—	4.25×10^{-7}
16	—	1.23	—	—	32	—
17	—	1.00	—	—	—	—
18	—	—	—	—	—	—
19	—	—	—	—	—	2.99×10^{-6}

TABLE IV (*concluded*)

No.	Heat capacity, sp. ht. between 17 and 100°C	Coeff. of thermal resistance	Heat conductivity. Kcal. m^{-1}. h^{-1}. $degrees^{-1}$	Thermal conductivity = heat conductivity / thickness × sp. ht.
1	—	—		—
2	—	—		—
3	—	—		—
4	—	—		—
4	—	—		—
5	—	—		—
6	—	—		—
7	—	—	about 0.9	—
8	—	—		—
9	—	—		—
10	—	—		—
11	—	—		—
12	—	—		—
13	0.221	6.24	—	—
14	—	—	—	—
15	0.2	7.1	0.7	1.4–1.5
16	—	—	—	—
17	—	—	—	—
18	—	—	—	—
19	—	—	—	—

No.	Surface conductivity	Dielectric constant	Electrical resistivity in megohms (=1000000 ohms)	Puncture voltage
1		—	—	—
2		—	—	—
3		—	—	—
4		—	—	—
5		—	—	—
6		—	—	—
7		—	—	—
8	above	—	—	—
9	300°C	—	—	—
10	the insu-	—	—	—
11	lating ability	—	—	—
12	of porcelains	—	—	—
13	ceases	5.73	—	—
14		—	170	100 KV/cm
15		5–6	—	—
16		—	$>10^6$	—
17		—	—	—
18		—	—	—
19		—	—	—

TABLE V

THE PHYSICAL PROPERTIES OF STEATITE

No.	Body	Sp. gr.	Bulk sp. gr.	Pore space %	Porosity by water absorption %	Absorption under pressure
1	Steatite Z.50	2.837	2.545	—	0	0
2	" Z.56	2.785	2.423	13.0	0	0
3	" Z.57	2.798	2.680	4.2	0	0
4	" Z.151	2.811	2.679	4.7	—	—

No.	Compressive strength kg/cm²	Tensile strength kg/cm²	Elastic strength kg/cm²	Modulus of elasticity kg/mm²	Torsional strength kg/cm²	Ball compressive strength
1	8637	283	748	9758	—	978
2	7528	—	851	—	—	—
3	6548	—	981	—	—	—
4	7423	320	846	10549	516	1824

TABLE V (*concluded*)

No.	Elastic strength under impact cm kg / cm²	Loss by abrasion. (rattler) Wt. loss in %	Hardness: Loss in sandblast Loss in cm³	Hardness: Scleroscope	Cone fusion Seger cone	Coeff. of linear expansion
1	2.83	4.8	2.1	—	15	8.3×10^{-6}
2	2.2	—	—	60	—	—
3	2.2	—	—	52	—	7.6×10^{-6}
4	2.24	3.4	1.27	—	—	—

No.	Heat capacity, sp. ht. between 17 and 100° C	Coeff. of thermal resistance	Heat conductivity Kcal · m^{-1} · h^{-1} · degrees^{-1}	Dielectric constant	Electrical resistivity in megeohms (=1000000 ohms)
1	0.202	3.57	2.15	—	—
2	—	—	—	—	—
3	0.206	4.28	2.4	5.4	2000000
4	0.193	3.95	1.2	—	—

E.J.V.

Recent experiments on the properties of steam at high pressures. H. L. CALLENDAR. *Engineering*, **122**, 649–50 (1926).—The properties of steam at 2000 lbs. per sq. in. have been investigated. The pressure was measured by a dead-weight gage; the experiments were conducted in a quartz tube surrounded by a silver cylinder heated electrically. Temperature was measured by a thermocouple calibrated against a Pt thermometer. When steam is highly superheated, its properties become simple; the equation to adiabatic expansion is of the same form as that for a perfect gas, *viz.*, $\frac{T}{P_{13}^{3}}$ = constant. The adiabatic index was calculated to be 1.30, and found by experiment to be 1.307. The specific heat of steam was found to be very close to Regnault's formula: $H = 606.5 + 0.305t_s + 0.48(t - t_s)$. H.H.S.

Pendulum apparatus for gravity determinations. G. LENOX-CONYNGHAM. *Engineering*, **122**, 271–72 (1926).—A three-pendulum apparatus designed by L. for the Cambridge School of Geodesy, and made by the Cambridge Instrument Co. H.H.S.

Color standardization. NATL. PHYS. LAB. *Engineering*, **122**, 113 (1926).—A vector colorimeter has been designed by J. Guild consisting of a Hilger constant deviation wavelength spectrometer combined with a Pointolite lamp, color filters, and 2 wedges adjustable in front of 2 collimators. It is possible to match any color by mixing the extreme red of the spectrum with some other spectral color. There are many problems involved, even apart from the difference between monorhythmic or monoperiodic radiation (which denotes a physical property) and the monochromatic color sensation. There is, for instance, no agreement at all as to what is understood by "white light" in different localities or as to the exact conditions under which color should be studied. H.H.S.

A rapid bolometer by sputtering on thin films. H. DEWHURST. Meeting Nov. 12, Phys. Soc. *Chem. and Ind.*, **45**, 905 (1926).—A sputtered film is used as bolometer for investigating the intensity of radiation from a heat source. While its sensitivity is only ½ of that of previous types of bolometer, the speed of response is 400% faster. The film, which may be as thick as only one wave length of light, is prepared by evaporating weak solutions of collodion, containing critical proportions of Canada balsam and castor oil, in ether and alcohol on the surface of clean mercury, and then transferring it to a metal ring and sputtering it with Bi by cathodic disintegration. H.H.S.

Hygrometer employing glycerine. E. GRIFFITHS AND J. H. AWBERY. (Meeting Nov. 12, Phys. Soc.) *Chem. and Ind.*, **45**, 905 (1926).—A variation of atmospheric humidity from 0 to 100% causes the refractive index of glycerine to change from 1.474

to 1.370 when the glycerin solution is in equilibrium with the air. There is a small temperature coefficient. H.H.S.

BOOKS

Chromium and its congeners. R. H. VALLANCE AND A. A. ELDRIDGE. London: C. Griffin & Co., 1926. Price 18*s*. H.H.S.

Beryllium and its congeners. J. C. GREGORY AND M. S. BURR. London: C. Griffin & Co., 1926. Price 18*s*. H.H.S.

Higher mathematics for students of engineering and science. F. G. W. BROWN. London: Macmillan & Co., 1926. Price 10*s*. H.H.S.

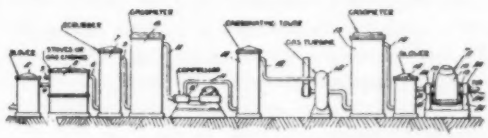
Das Polarisatione—Mikroskop. H. AMBRONN AND A. FREY. Leipzig: Akademische Verlagsges. m. b. H., 1926. Price 13.5 M. H.H.S.

Surface equilibria of colloids. P. LECOMTE DU NOÜY. New York: Chemical Catalog Co., 1926. Price $4.50. H.H.S.

PATENTS

Process for the removal of borax from alkali-metal nitrates. C. F. BOOTH AND PAUL LOGUE. U. S. 1,610,485, Dec. 14, 1926. The hereindescribed process for removing borax from nitrate solutions, which consists in dissolving nitrate and precipitating the borax by the addition of lime and magnesia.

Process for the manufacture of sodium bicarbonate and the production of nitrogen. E. E. ARNOLD. U. S. 1,611,401, Dec. 21, 1926. The process for obtaining sodium bicarbonate and nitrogen which comprises, burning waste blast furnace gases in air to convert the carbon monoxid and hydrogen content thereof to carbon dioxide and water with proportionate increase in the nitrogen content, compressing the gaseous mixture thus formed and passing it into contact with ammoniated brine while under a pressure considerably in excess of the hydrostatic pressure exerted by the ammoniated brine.



General

Too many ceramic schools? EDITORIAL. *Bull. Amer. Ceram. Soc.*, **5** [12], 441–44 (1926). —Various criticisms of ceramics chools and their value are discussed in this editorial. The need for especially trained men which is developed by sound industries is shown and the growth of engineering schools traced. More specialization in ceramics is argued by the record of achievement by fundamental scientists. The various courses which have been stressed as needed for the training of ceramic men in the various branches are mentioned. The chief criticism made of ceramic schools is that they should eliminate recapitulation and work forward at all times, and unite the ceramic manufacturers in support of ceramic research and education. E.J.V.

Factory management—the pivot man and his relation to industry. W. E. DUNWODY. *Bull. Amer. Ceram. Soc.*, **5** [12], 459–63 (1926).—The great amount of money being charged to waste in industries is decried. Results of surveys to determine the amount of waste due to lack of coöperation between employers and employees are presented. The old system of making the best workmen bosses as business increased and larger organizations were necessary is criticized because no effort was made to develop these bosses into "pivot men" who are not only managers but leaders and teachers of the men subordinate to them. The pivot men must have the confidence and respect of the workers and the ability to "sell" sound constructive thinking to them. Special training of pivot men is urged. E.J.V.

The human element in brick making. JAMES P. MARTIN. *Bull. Amer. Ceram. Soc.*, **5** [12], 463–67 (1926).—The human element is of greatest importance in successful brick making. This paper is written to invite a study and discussion of the human elements in brick making, and, perhaps, open new lines of thought in solving some of the problems in brick making. Examples are cited which show the importance of the human element, the need for thought on the part of all persons connected with the operation of a plant, and methods of relieving monotonous jobs of some of their monotony. E.J.V.

Bureau of Standards celebrates 25th anniversay of founding. ANON. *Amer. Glass Rev.*, **46** [10], 34 (1926). Reprinted from *Chem. Met. Eng.*—A tribute summing up its notable contributions to business during the 25 years of its existence. E.J.V.

Startsman heads National Glass Distributors. WEARY WANDERER. *Amer. Glass Rev.*, **46** [11], 25 (1926); *Nat. Glass Budget*, **42** [33], 3 (1926).—An account of the annual meeting of the National Glass Distributors' Association held in Pittsburgh on Dec. 7 and 8. Brief abstracts of addresses presented are given. D. H. Startsman of Cincinnati, Ohio, is the new president. E.J.V.

U. S. Potters in session. ANON. *Pottery Glass and Brass Salesman*, **34** [19], 7–9 (1926).—A brief general report on the forty-eighth annual meeting of the U. S. Potters' Association held in New York. Thomas B. Anderson of the Pope-Gosser China Co., is new president. E.J.V.

A ten years' retrospect. WALTER BUTTERWORTH. *Glass Ind.*, **7** [12], 289 (1926).—Abstracts from the presidential address to the Society of Glass Technology, reviewing the first 10 years of its existence. E.J.V.

Ford reveals his business methods. ANON. *Ceram. Ind.*, **7** [6], 655–60 (1926).—A review of "Today and Tomorrow," a book by Henry Ford in collaboration with Samuel Crowther. F.P.H.

Manufacturing prosperity. ANON. *Brick Clay Rec.*, **69** [11], 820–24 (1926).—A review of the book "Today and Tomorrow" by Henry Ford in collaboration with Samuel Crowther. Mr. Ford talks of his methods, his theories and his reason for success. F.P.H.

American Ceramic Society at big mid-west meeting asks for research to aid in solving plant problems. ANON. *Ceram. Ind.*, **7** [6], 666 (1926).—A report of papers presented at mid-western meeting of the AMERICAN CERAMIC SOCIETY. These dealt with plant problems which could probably be best attacked from a scientific angle and solved in the laboratory with the coöperation of the factory. F.P.H.

Ohio Ceramic Industries Association adopts active program at reorganization meeting. ANON. *Ceram. Ind.*, **7** [6], 668 (1926); *Brick Clay Rec.*, **69** [11], 825–26 (1926).—The purpose of this Association is discussed. The Association has interested the Ohio State University and the state authorities in having a state-owned brick yard equipped for experimentation and the plant proving of laboratory findings. A number of research fellowships have been established by members of this Association in the Engineering Experiment Station. Fifteen problems for research were suggested by members of the whiteware division. F.P.H.

Face brick's greatest meeting. ANON. *Brick Clay Rec.*, **69** [12], 886–91 (1926).—A report of the fifteenth annual meeting of the American Face Brick Association. A progress report on research work carried out for the Association on the subject of scumming and efflorescence was presented by F. W. Butterworth from information obtained by L. A. Palmer. A few facts presented were: Efflorescence is caused by soluble salts in the building materials. Among these mortar is the chief offender. Adding 2% of calcium stearate or ammonium stearate to the mortar will prevent

efflorescence. Waterproofing the mortar is also a good preventive. To prevent drier scum: Keep the temperature as high as possible. Keep the humidity as low as possible. Use indicators to indicate the sulphur condition in the drier. Move air through the drier as rapidly as possible. Use a minimum amount of pugging water. Regarding kiln scum: All coal contains ½% of sulphur or more which is enough to do the damage. Intelligent lengthening of the firing time will aid in preventing the formation of scum.
F.P.H.

Protecting your ideas and inventions. L. T. PARKER. *Brick Clay Rec.*, **69** [12], 908–909 (1926).—Gives advice on filing patent applications and securing protection.
F.P.H.

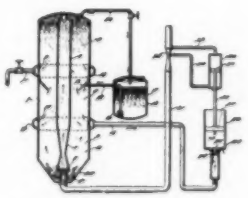
Ceramics at the Sesquicentennial. L. M. NORTON. *Ceramist*, **8** [8], 508–16 (1926).—N. describes the outstanding features of the different exhibits of ceramic ware at the Sesquicentennial Exposition, among which were exhibits from North Carolina, Arkansas, Connecticut, New Jersey, Pennsylvania, Spain, Holland, Denmark, England, France, Czechoslovakia, Hungary, Austria, Jerusalem, Persia, China, Japan, and Africa. The location of these exhibits is given, as well as other exhibits of interest to ceramists.
A.E.R.W.

Ohio Ceramic Industries Association holds meeting. ANON. *Ceramist*, **8** [8], 517–23 (1926).—An account of the meeting held at Columbus, Ohio, Nov. 12 and 13. An abstract of the address by J. L. Murphy, outlining the future plans of the organization is given. The plans provided for the securing of proper appropriations for research work, the prevention of unjust tax discrimination, the prevention of unjust freight rates, the coöperation in prison labor, the operation of a large experimental plant, and the solution of fuel problems are outlined. The production and absorption of efficient ceramic graduates are discussed. Reports of several speeches are given.
A.E.R.W.

High temperature insulation. ANON. *Engineering*, **122**, 571 (1926).—Discusses statement of U. S. Lt.-Comm. C. S. Gilette that American practice is to use diatomaceous earth as heat-insulator for temperatures above 500°F, and 85% magnesia only for temperatures below 500°. British practice is to use 85% magnesia up to 700°F, an efficiency of 93% being obtained at that temperature. H.H.S.

Oil fuel for steam boilers. C. E. STROMEYER. *Engineering*, **122**, 667 (1926).—The importance of maintaining a full supply of air to the burners is emphasized, since otherwise partially burned fuel gets into the flues, where it may re-ignite and cause serious damage. Cases are mentioned of injury thus occasioned to a side-flue and to an economizer. Oil fuel provides long flames, so that steel plates may be exposed to high temperatures, and should therefore be kept free from scale. Seams in particular require protection from the direct impact of flame. If coal and oil are being used simultaneously, it is best to burn them in separate furnaces. H.H.S.

PATENT



Method of and apparatus for the continuous softening of water by the use of zeolites. C. H. NORDELL. U. S. 1, 608, 661, Nov. 30, 1926. A continuous water-softening method which consists in dividing a quantity of zeolitic material into 3 sections, causing a progressive transfer of material from one section to another in endless cycles, passing water to be softened through a portion of the material in one of the sections, regenerating a portion of the material while it is passing through another of the sections, and washing a portion of the material while it is passing downwardly through the third section.

Removal of iron from clays, bauxites, etc. H. FLEISSNER. Austrian Pat. 102,553, Aug. 7, 1923. Before being treated with dilute acids, clays are subjected to the action of hydrogen sulphide to remove the iron. The iron sulphide formed is best decomposed with sulphur dioxide or with gases containing it. (*Brit.C.A.*)

Process and apparatus for purifying clay, etc. F. PARENTANI. Eng. Pat. 255,300, Dec. 2, 1925. Coloring impurities are removed from clays and similar materials by treating them in the dry state with hydrogen sulphide at atmospheric temperature. The material may first be subjected to the action of a vacuum. It is finally treated with an acid solution (hydrochloric acid) to dissolve the sulphides formed, the hydrogen sulphide produced being used to treat further material. (*Brit.C.A.*)

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Superstitute

Can You Coin a Better Word?

Read this Editorial from January Industrial and Engineering Chemistry

WANTED—A WORD

The idea of inferiority is associated in the minds of most of us with the word "substitute," and probably the word originally had no other meaning. We know that the products of today which are used to replace those of yesterday are more often superior than inferior, and yet they are commonly described as substitutes. Note the series of progressive substitution without inferiority in the development of illumination. Venetian lamps were substitutes for pine knots, tallow dips for Venetian lamps, whale oil for tallow dips, kerosene for whale oil, artificial gas for kerosene, the electric lamp for gas, and now the gas-filled tungsten filament incandescent for the old style carbon lamp. Originally substitutes, each, in turn, became a successor.

There are any number of similar examples of materials or devices actually taking the place of those previously in use and generally with a marked improvement. They are without inferiority, yet when described as substitutes the original meaning of the word rises in our minds to the detriment of the innovation.

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has been suggested by the Editor of Industrial and Engineering Chemistry.

OPAX will appreciate the receipt of your suggestion for an acceptable "Superstitute" for the word "Substitute".

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 6 February, 1927 No. 2

EDITORIALS

FEDERAL AND STATE SUPPORT OF EXPERIMENT STATIONS

Are the Industries Getting Their Just Proportion?

No one believes that less aid by the governments should be given to the agricultural experiment stations. But who would not wonder why a large share of the total money available for experiment stations should not be used in support of industrial research?

Here are the figures for 1925–1926.

	Federal and state appropriations agricultural experiment stations	State appropriations engineering experiment stations
Arkansas	$ 890,000	$ 6,000
Colorado	2,015,065	62,390
Illinois	5,100,616	1,112,380
Iowa	3,501,383	510,000
Kansas	1,629,154	61,750
Maine	1,017,000	0
Maryland	1,480,485	21,000
Michigan State	2,544,789	21,000
Nebraska	1,963,000	0
Missouri	370,000	110,000
Ohio	6,779,872	81,350
Pennsylvania State	1,341,000	82,845
Purdue	3,192,090	187,400
Texas	3,244,000	14,000
Washington	2,031,350	35,000
	$37,100,404	$2,205,115

DISTRIBUTION OF GRADUATES OF CERAMIC ENGINERING JUNE, 1926

Ceramic Schools	*Founded*	*1925 Registr.*	*Total Grads. to Date*	*Grads. 1925*	*Not Class.*	*Art*	*Metal Eng.*	*Glass*	*Heavy Clay*	*Fire Ref.*	*Terra Cotta*	*Pottery*	*Research and Training*	*Misc.*	*Out*	*Dead*	*Totals*	*Out*
Ohio State	1895	38F 28S 32J 9Sr	207	14	20		8	10	36	18	13	14	20	13	23	32	207	13%
N. Y. State	1900	130 Und. ?J-6 Sr.	88	15		1			27	8	2	3	7	5	4		57	7%
Rutgers	1902	19 Und. 6J-5 Sr.		4														
Illinois	1905	77 Und. 12 Sr.	143	15	41		3	5	27	9	7	4	15	13	10	9	143	7.4
Iowa State Coll.	1906	32 Und. 8 Sr.	25	6		1	3	1	11	2	—	1	1	1	4		25	16.0
North Dakota	1910	Gives 6 classes Ceramics; No degrees req. for Min. Eng.-Gen. Eng.																
Washington	1918	4 Und. 4 Sr. 8 Spec.	9	2					3	4	1		1				9	
Saskatchewan	1921	4 Und.	2	0					1	1							2	
Penn. State	1922	4F-6S 6J-1 Sr.	0	0	No. Grad.													
North Car. State	1923	250 Ext. Stud.	0	0	No. Grad													
Georgia Tech.	1924	8	0	0	No. Grad.													
Toronto	1925	2 Sr. 2 Spec.																
Louisiana	1926	0 Students																
				56	61	2	14	16	105	42	23	22	44	32	41	41	443	
				%		0.5	3.7	4.2	27.4	11.0	6.0	5.8	11.6	8.4	10.7	10.7	—	10.7

The discrepancy is apparent. The underlying reason for this discrepancy is in the fact that the agricultural interests have their "Grange" always actively presenting their need of information and always scheming to obtain it. In this the farmers are in unanimous agreement; 100% strong, for all farm owners are members of the Grange.

The manufacturers are in several separate groups, each believing that the diversity of their products makes a common interest impractical.

The farmers play the game as a well-drilled team whereas the manufacturers play the game as independent performers. Team playing always wins. A team of individually playing stars can never cope with the effectiveness of well-coördinated team playing.

The ceramic manufacturers have so much in common in the fundamentals of ware production that they have every reason to federate through a Ceramic Research Council to obtain from the existing agencies that which these agencies are ready and willing to give in facts fundamental and applied.

NINETY PER CENT OF CERAMIC GRADUATES ARE PRACTICING CERAMICS

The record shows that nearly 90% of those who pursued the study of ceramics for the four years required to obtain a collegiate degree and are now living have continued in ceramics. Several of these graduates hold responsible well paying jobs and several are plant owners.

This record is evidence that the ceramic industrial managers realize the importance of specially trained plant and process directors. This places on the ceramic instructors the responsibility of so preparing the graduates that they may most effectively serve in the industries.

We believe that the work of the ceramic technologist, the ceramic engineer and the ceramic artist are quite different in all respects and that for the most efficient service in each the man must have a distinctive qualification by nature and by training.

PAPERS AND DISCUSSIONS

VITAL PHASES OF CONSTRUCTIVE WORK IN CLAY[1]

By Mary E. Cook

That the abnormal phases of present day life are indications of vital needs in our educational life as it touches our great industries, I feel sure we are all agreed.

The perfecting of mechanical means of production has tended to make of man a mere projection of the machine, which further mechanical development will eliminate entirely, if we are satisfied as a nation with our present status of culture in art.

Our first Americans had the pure joy of creating to supply needs, and many happy moons were spent in putting beautiful form and lovely pure color into the things of everyday life; all the symbolism of Nature's wonders made life a beautiful story.

The white man, introducing the god of speed, suppressed most of this spontaneous art that belongs to America.

Machines have almost become our gods; we run in masses, estimate our greatness by mass production; height and breadth and width of masses of stone, brick, and steel, we call cities, great cities. Love of beauty is still strong in us, but it is so much quicker, so much easier to buy beauty from other lands, than to create it.

The machine is almost perfected; it can produce much more than we need, and there is nothing for the younger generation to do.

His eyes and hands are holden except to expertly apply himself as a guide to the auto to go to and fro with the masses. He does not see how he can apply knowledge forced upon him in school and college.

Everything has been abstract; and once in a while the concrete thought comes, perhaps when wandering through a museum, as to what made "the guy" think of creating a thing of beauty like that.

The sleeping angel of creative thought needs waking!

Work and work habits, together with a high degree of intelligent appreciation, the ability to think a subject through to completion and then to execute or carry out the thought, are generally conceded to be the essential elements in the production of a worthwhile citizen of a democracy.

In our eagerness to give the youth of today culture and appreciation, we have rather lost sight of the importance of the youth's power of assimilation and the needed development of the constructive faculty; are we not smothering and suppressing individual development by

[1] Received December 15, 1926. For presentation at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Art Division.)

giving, when one of the inevitable and unbreakable laws of development is that one must *earn* through thought and work the privilege of dwelling in the realm of creative constructive thought.

The rapid accumulation of wealth in America gives us unlimited power for art in the great cultural sense to be incorporated in our daily life through the coöperation of national, state, and private interests, fostering the establishment of art schools, these to be of a high standard and eminently practical.

In the clay industries what a field is here in America; our natural resources scarcely touched; from a purely commercial standpoint, what an opportunity is open in the South and West, all over our land!

On the other hand, what of the army of young men and women graduating from our schools and universities into a mob of *drifters*! Most of them are wholly undeveloped mentally; they have studied and recited the same things in the same way everyone else was doing; absolutely without initiative or constructive thought when with the crowd.

Take them individually and you will find a restless longing for creative expression; a longing to *do*, but they have not been trained to do; hence, the mad rushing to and fro to find they know not what, so they just keep moving with the crowd.

We take our culture en masse and hence at present there is some indication of cultural nostalgia; we cannot assimilate the beauty of the ages in a three months' trip to Europe, or in three days in the Metropolitan Museum. However, on the bright side, all indications point toward a beginning of a virile constructive age in America. In raw material, both human and mineral, there lies before us a fascinating problem involving in its solution the awakening of humanity to the latent beauty in our fair land, prisoned in hills, valleys, and mountains, waiting for the creative thought to incorporate it into man's life in forms of beauty and utility.

Scientifically and commercially we can achieve this transformation, but that is not enough; nothing is complete in this life until the touch of the infinite perfects it. Our marvelous mechanical inventions are scientifically good and more effective when they conform to the great laws of beauty of line and form, that govern the creation of the universe.

With clay as our medium, the vast possibilities for creative work are immeasurable; it has been the chosen medium in which to record the life of man on the earth; the lowest and the very highest creative thought has found in all the ages, among all people, nothing to supersede it.

Responsive to man's touch and thought, it belongs fundamentally to the constructive eras that appear among men after the chaos of a

destructive era of wars and darkness. Such an era has arrived in the history of man's life on this earth. The need is great and the time ripe for a moral, spiritual, mental, as well as commercial development.

How shall the need be met in America?

Commercial supremacy today means not quantity production alone but quality as well.

In what way, all agreed, can this little group help to bring back the harmony of life and give man again possession of his inheritance, the right to re-express in clay the great truths of universal life.

First of all, the youth must be given the opportunity to find himself and we are all agreed this opportunity can be given him through efficient schools.

It has been conceded that to the chariot of commercial supremacy in clay products must be harnessed the invincible team, art and science. The day of man's being merely an extension of a machine is passing and the demand for quality in design and color, as well as in the material itself has come.

We have the example and inspiration of the older countries to facilitate our development of methods of instruction.

France, whose government has consistently fostered the development of the industrial as well as the fine arts since the time of Henry IV, when cabinet makers were housed in the galleries of the Louvre, is at the head of European nations and the world in the fine arts.

She has been keenly alive to the fact that the artistic taste and skill of her people represented a national asset and has fostered schools of art and museums to encourage her fullest development.

The National schools of fine arts and of decorative arts, as well as certain schools connected with the national manufactories, are entirely supported by the government. Since 1824, one of the Cabinet offices has been a Ministry of Public Instruction and Fine Arts, which exercises supervision over all art schools in France.

Thus the standard of the schools is never lowered, but is always being stimulated to rise to higher levels of excellence.

In establishing new schools, local authorities are expected to contribute two-thirds and the Government one-third of the expense.

Emphasis is laid upon the holding of evening classes in these schools so that artisans employed during the day can avail themselves of the opportunities thus offered.

The Ministry inspectors examine the working of the schools and report on the work produced by the pupils. These reports are communicated to the departmental and municipal authorities who are thus informed of the success achieved in the schools.

In cases where progress is noted, the state encourages the students by rewards or prizes and the general councils of the departments or municipalities award school or traveling scholarships. Each year a session of examinations conducted by the Government is held in Paris through which the certificates of proficiency for instruction in drawing in the lycées and colleges are obtained. This session is open to all candidates from Paris and the provinces.

Every two years a session of examinations is held at Paris to obtain the certificate of proficiency for instruction in decorative composition.

Finally, a normal session of the applied arts takes place each year.

These sessions are composed of the principal art manufacturers, artists engaged in the industrial arts, art critics, and directors and professors of drawing schools, the municipalities generally defraying expenses of the latter.

The French policy of state grants to departmental and municipal schools of art obviously assists in building up and maintaining a wide-spread system of art instruction throughout the country. The plan of state inspection tends to maintain the high standard of the schools as the experience of the whole nation is thus brought to bear on each school. In the same way the system of state examinations insures a high standard of ability and culture in the staffs of instructors. In the schools, freedom of individual expression has been encouraged with excellent results. In the various art schools the methods and courses vary according to the needs and demands of the local industries.

Schools that have to do directly with the training of designers are represented first by the system of national schools of decorative art (écoles nationales des arts decoratifs) located in Paris, Aubusson, Bourges, and Limoges, and industrial art schools located at Roubaix, Saint Etienne, and Rheims. Their instruction to a large extent is adapted to the local industry. In addition to the maintenance of the Écoles Nationales des Beaux Arts and Écoles Regionales des Beaux Arts in the various cities of France, there are many industrial art schools maintained by the municipalities, most notably in Paris, the École Bernard Palissy specializing in ceramics, design, and carving, and the School Nationale at Sèvres.

Children of thirteen years of age are admitted to the industrial art schools and the thoroughness with which the technical side of every craft is taught in the French schools, we may well take to heart.

Not too early can the child learn that coördination of hand and brain without which no great designer, craftsman, or artist is developed.

A La Manufacture Nationale de Sevres

The École Nationale de Ceramique was founded for the development of expert technicians for the Ceramic Industries.

The school is supported by the state and administered by the Ministry of Fine Arts, the director of the manufacture and the director of the school.

There is no advisory committee, but a number of prominent manufacturers of ceramics are members of the Jury of Examination.

The Institution is well equipped on the technical side with chemical laboratories, modeling rooms, turning rooms, furnaces, and lecture halls. The famous Ceramic Museum of the Manufacture de Sèvres is at the service of the student.

Students are admitted at the age of eighteen years. All instruction is free of charge; only seven pupils admitted each year, five boys and two girls; the number applying is three times as many as admitted, offering opportunity for selection. The length of the course is four years.

There are eleven teachers in these courses, many graduates of the school, or from men prominent in the industry, one teacher of design a graduate of a French art school. The effort of the school is to develop technical ceramic experts, qualified to fill any position in this important French industry.

The designer is only an incidental product and instruction in design forms only a small part of the course. Theoretical instruction is given in classes, while the practical instruction is given individually. The larger per cent of the graduates enter the industry as organizers, producers, expert technicians, and superintendents of manufacture.

Only a small percentage of the French ceramic designers have had experience in this school, and as a preparation for work in design, the course is not considered by the industry as an important means of training.

L' École Nationale D'art Decoratif de Limoges

This school was founded in 1868 and in 1891 became a National Art School. The object of the School is to train boys and girls to enter the artistic side of the main industry of Limoges, the center of French ceramic production.

The school is amply equipped with technical laboratories, modeling and drawing rooms, lecture halls, ceramic workshops, and an excellent ceramic museum.

The teachers are selected from the French art schools. Students are admitted between the ages of twelve to sixteen as a result of competitive examinations and no charge is made for instruction.

A general preparatory course and a special course are offered. The former is planned as a general art education and the latter is for those preparing themselves for the ceramic industry and enrolls many apprentices in the trade.

The school is open eleven months in the year. The hours are: girls, from 8 to 12 and 1 to 3; boys, 11 to 2, and in the evenings from 8 to 10. Length of course is from three to five years.

The courses are:

(*a*) General Course: geometrical drawing; perspective; architecture; free hand drawing; elementary design; flower drawing; figure and animal drawing; anatomy; composition of ornament; history of ornament; principles of botany as applied to ornamentation; studies and sketches from ceramic products; history of art; modeling of flowers, animals, and figures; special instruction for decoration of ceramics, particularly porcelain.

(*b*) Special Course: flower painting in water color and oil and pastel china painting; etching for ceramics; drawing from casts and from life; drawing from plants; painting on plates, cups, vases, etc., with technical explanations as to choice of color, enameling, heat of ovens and kilns.

The students are first given a thorough training in drawing from casts and living objects. Later on they are required to make a sketch for a ceramic decoration and by carrying out this sketch in the actual material become familiar with the various ceramic processes and technical requirements.

Teachers have had practical experience.

No craft work or designs made in the schools are sold.

Sixty per cent of the pupils remain through the whole course. The largest per cent enter the industry as ceramic workers.

About one-fifth go into the designing rooms of industry.

In France, as in this country, there are among the manufacturers the men of vision who recognize the value of industrial art instruction as given in the schools, and avail themselves of its benefits and lend their fullest coöperation.

Schools alone will not give America the cultural education it needs. It is but one of the vital elements in our art progress. The general atmosphere of public and private life is of vast importance and needs every stimulation possible, through museums, exhibitions, lectures, great architecture, and sculpture in public buildings, gardens, and parks, and emphatically the finer treatment of the common things of life.

Such conditions in a nation's or a city's life tend to crystallize the wandering, purposeless life of youth into one of constructive thought and aspiration. That will awaken the latent creative power to find a purpose and means of expression in the natural resources of his state, his country. What man has done, he can do, to find in work the real joy of life, when work becomes a means to find himself and to play through his chosen medium his little part in the great harmony, a citizen of the great democracy, compounded of brain, of heart, and of soul.

1515 Clifton Road
Columbus Ohio.

ACTIVITIES OF THE SOCIETY

1927 ANNUAL MEETING

Hotel Book-Cadillac, Detroit
February 14-18 inclusive

Seven Divisions meeting simultaneously, excellent program of papers and reports, very worthwhile plant trips, and an interesting social entertainment are planned features.

The Art Division has arranged a product exhibit that is attractive and instructional.

One and one-half excursion rate has been granted by the passenger associations. Secure a certificate at place and time of purchasing one way fare to Detroit. Visé of certificate at Meeting will be accepted for purchase of one-half fare return trip where one way fare is 79c or more.

Financial Report for 1926

American Ceramic Society,
Columbus, Ohio.

Columbus, Ohio,
January 15, 1927.

Gentlemen:

I have audited the accounts of the AMERICAN CERAMIC SOCIETY for the year ending December 31, 1926, and herein submit my report:

Attached to this letter as a part of this report are the following statements:

I—Statement of Assets and Liabilities, as of December 31, 1926.

II—Profit and Loss Statement for the year ending December 31, 1926.

All cash received has been promptly deposited in bank, from which all payments have been made by voucher check signed for the AMERICAN CERAMIC SOCIETY by the Treasurer and Secretary and countersigned by the President. For convenience in paying small current items, a revolving fund of $300 is carried in a separate bank account. Checks on this account are drawn by the Assistant Secretary, and the fund is reimbursed (usually monthly) by voucher check from the main checking account.

The inventories seem to have been accurately taken and conservatively priced. Copies on hand of the earlier issues of the Journal have been priced on a different and more conservative basis than heretofore, which reduces the value at which they have been carried and shows a loss on this item for this period.

After a careful examination, I hereby certify that it is my opinion that this Report correctly shows the financial operations of the AMERICAN CERAMIC SOCIETY for the year ending December 31, 1926, and the true financial condition at the close of that year.

Respectfully submitted,
A. L. Peters
Certified Public Accountant.

STATEMENT I

AMERICAN CERAMIC SOCIETY
STATEMENT OF ASSETS AND LIABILITIES
As of December 31, 1926

Assets:		
Cash in Bank, (General Account),	5,022.87	
Cash in Revolving Fund,	300.00	5,322.87
Liberty Bonds,		4,700.00
Accounts Receivable,		2,375.62
Inventories:		
Journal, 1918–1925,	2,040.60	
Journal, 1926,	332.30	

Transactions,		555.00	
Collective Indexes,		103.50	3,031.40
Furniture and Fixtures,			1,383.20
Total Assets,			16,813.09
Liabilities			
Accounts Payable,	1,994.62		
Notes Payable,	219.10	2,213.72	
Prepaid Dues:			
Divisions,	257.80		
Corporations,	1,045.00		
Personal,	1,719.70	3,022.50	
Prepaid *Journals*,		1,027.99	
Net deferred Income on Bibliographies,		70.29	
TOTAL LIABILITIES AND DEFERRED INCOME,			6,334.50
SURPLUS, December 31, 1926,			10,478.59

STATEMENT II
AMERICAN CERAMIC SOCIETY
PROFIT AND LOSS STATEMENT
For the Year Ending December 31, 1926

			Losses	Gains
Net Gain on Divisions,				131.36
Earned Dues—Corporation,		6,847.00		
Personal,		15,082.21		21,929.21
Collective Indexes—Sales,		11.90		
Decrease in Inventory,		14.40	2.50	
Interest on Liberty Bonds,				199.75
Journal, 1926—Sales,		3,629.60		
Advertising,	15,573.32			
Less Commission,	1,566.17	14,007.15		
		17,636.75		
Printing (Less Inv.),	13,264.33			
Abstracts,	677.21	13,941.54		3,695.21
Journal, 1918–1925—Sales,		1,222.88		
Decrease in Inventory (See text),		2,290.40	1,067.52	
Reprints—Sales,		1,326.69		
Costs,		1,846.74	520.05	
Seger's Writings—Sales,		67.50		
Costs,		56.66		10.84
Transactions—Sales,		330.00		
Costs (plus Inventory decrease),		335.00	5.00	
Reports of Committee on Standards—Sales,		22.10		
Decrease in Inventory,		15.70		6.40
Totals,			1,595.07	25,972.77
Gross Gain on above activities carried down,			24,377.70	
			25,972.77	25,972.77
Gross Gain brought down,				24,377.70

General Expenses:			
Salaries,		11,643.28	
Office Expense—Secretary,	3,158.66		
Editor,	1,912.83		
President,	5.00	5,076.49	
Postage,		1,833.51	
Traveling Expense,		1,046.84	
Meeting Expense,		1,410.28	
Expressage,		247.54	
Committee Expense,		484.26	
Atlanta Meeting Expense,		78.00	
Miscellaneous Expenses	76.10		
Less Misc. Income	47.30	28.80	
Depreciation on Furniture and Fixtures,		129.75	
Bad Accounts Written Off,		242.29	
Total General Expenses,			22,221.04
NET PROFIT FOR THE YEAR,			2,156.66

SURPLUS ACCOUNT

Balance December 31, 1925,	8,321.93
Profit for the year 1926,	2,156.66
Surplus Balance December 31, 1926,	10,478.59

NEW MEMBERS RECEIVED FROM DECEMBER 16 TO JANUARY 15

PERSONAL

Charles R. Amberg, student, Alfred University, Alfred, N. Y.
Clarence T. Bennett, student, Alfred University, Alfred, N. Y.
Edwin J. Bognar, graduate student, Ohio State University, Columbus, Ohio.
Arnold Bookheim, student, Alfred University, Alfred, N. Y.
J. M. Buchanan, Asst. Supt., Dando Works, McLain Fire Brick Co., Beaver, Pa.
Guy M. Burnand, Ceramic Dept., Johnson Matthey & Co., Ltd., London, England.
Starr E. Cogswell, Clay Products Inspector, Western Weighing and Inspection Bureau, Chicago, Ill.
William G. Collins, student, Alfred University, Alfred, N. Y.
Edward F. Creevy, Jr., student, University of Illinois, Urbana, Ill.
Harry H. Davidson, Chief Engineer, Mullite Refractories Co., Seymour, Conn.
Cecil G. Denney, Industrial Fellow, Mellon Institute, Pittsburgh, Pa.
Wm. L. Fabianic, student, Alfred University, Alfred, N. Y.
Luther D. Fetterolf, Research Assistant, University of Illinois, Urbana, Ill.
Ray C. Fulmer, student, Alfred University, Alfred, N. Y.
Charles B. Garwood, Factory Manager, Carr-Lowrey Glass Co., Baltimore, Md.
Joseph W. Gill, Chemist, Port Clinton, Ohio.
H. R. Goulding, student, Georgia School of Technology, Atlanta, Ga.
Samuel F. Grant, Tile Salesman, American Encaustic Tiling Co., Zanesville, Ohio.
F. W. Green, student, Georgia School of Technology, Atlanta, Ga.
C. F. Greene, student, Georgia School of Technology, Atlanta, Ga.
Jack R. Grout, Jr., Ceramic Engineer, Acme Brick Co., Danville, Ill.
E. R. Hannah, student, Georgia School of Technology, Atlanta, Ga.
Wm. Henderson, student, Georgia School of Technology, Atlanta, Ga.
W. Henrichs, Chemist, Hazel Atlas Glass Co., Clarksburg, W. Va.

Carroll C. Highbarger, Botfield Refractories Co., Swarthmore, Pa.
Tajamal Husain, student, Alfred University, Alfred, N. Y.
John B. Ives, Burn Despatcher, Laclede Christy Clay Products Co., St. Louis, Mo.
George Johnson, student, Georgia School of Technology, Atlanta, Ga.
Frank B. Kelley, Artist and Potter, Reuss Pottery, Norwalk, Conn.
Gordon Margetts, Laboratory Assistant, Gladding, McBean & Co., Alberhill, Calif.
E. B. Merry, student, Georgia School of Technology, Atlanta, Ga.
Francis D. McNerney, student, Alfred University, Alfred, N. Y.
Albert J. Monack, student, West Virginia University, Clarksburg, W. Va.
Robert T. Murphey, student, Ohio State University, Columbus, Ohio.
Lamont Myers, Jr., student, Georgia School of Technology, Atlanta, Ga.
Thomas E. Nicholson, Ceramist, Gladding, McBean & Co., Auburn, Wash.
Clair R. Oberst, Supt. of Construction, Harrop Ceramic Service Co., Columbus, Ohio.
Patrick D. Perrone, student, Alfred University, Alfred, N. Y.
E. F. Powell, student, Georgia School of Technology, Atlanta, Ga.
Frederick W. Reisman, Pres. and Gen'l. Mgr., Keystone Refractories Co., 120 Liberty St., New York, N. Y.
C. L. Renfroe, student, Georgia School of Technology, Atlanta, Ga.
Eben Rodgers, student, Georgia School of Technology, Atlanta, Ga.
Stanley S. Saunders, student, Alfred University, Alfred, N. Y.
B. S. Schwetzoff, Director of States Exp. Inst. of Silicates, Moscow, U.S.S.R.
James R. Smith, Sr., Treasurer and Mgr., New Jersey Porcelain Co., Trenton, N. J.
Jessie A. Stagg, Sculptor-potter, 141 Broadway, New York, N. Y.
Norman H. Stolte, student, Alfred University, Alfred, N. Y.
Nathan F. Tucker, student, Alfred University, Alfred, N. Y.
Harry Voorhies, Mgr., Inwood Pottery, West 207th St. and Ship Canal, New York, N. Y.
W. E. Waters, student, Georgia School of Technology, Atlanta, Ga.
C. W. West, student, Georgia School of Technology, Atlanta, Ga.
Ruth D. Whitford, Teacher, Collinwood High School, Cleveland, Ohio.
R. E. Whittenberg, student, Georgia School of Technology, Atlanta, Ga.
Herman G. Wilcox, student, Alfred University, Alfred, N. Y.
Leland E. Williams, student, Alfred University, Alfred, N. Y.
Thomas J. Zopfi, Purchasing Agent, Buckeye Clay Pot Co., Toledo, Ohio.

CORPORATIONS

Acme Brick Co., Adams Bldg., Danville, Ill. Douglas F. Stevens, representative.
Bedford Mining Co., Inc., Bedford, N. Y. Leo L. Hunt, representative.
Maryland Glass Corp., Morrell Park Station, Baltimore Md. Louis C. Roche, representative.
G. H. Morton & Son, Elsinore State Bank, Elsinore, Calif.

Membership Workers' Record

	PERSONAL	CORPORATION		PERSONAL	CORPORATION
E. deF. Curtis	4	1	C. W. Parmelee	1	
F. C. Flint	1		Stuart M. Phelps	1	
Meyer L. Freed	1		F. H. Rhead	1	
F. M. Hartford	1		Douglas F. Stevens	1	1
A. V. Henry	14		W. E. S. Turner	1	
E. C. Hill	1		Thomas Walker	1	1
John B. Lyon	1		Arthur S. Watts	1	
Paul S. MacMichael	1		Frank C. Westendick	14	
Clarence B. McComas	1		Fred Whitehead	1	
T. N. McVay	1		Office	7	1
Ralph J. Paddock	1		Total	56	4

NEWS FROM MEMBERS OF THE SOCIETY

Edwin P. Arthur has notified the Secretary that for the next few months his address will be Box 77, Vienna, W. Va.

On January 1, 1927, the firm of the **Atlas China Company** of Niles, Ohio merged with the **Globe China Company**, Cambridge, Ohio.

R. F. Brenner has moved from Parkersburg, W. Va. to Torrance, Calif.

Samuel Breskow, formerly of Pittsburgh, has removed to 3829½ Rokely St., Chicago, Ill.

Lawrence H. Brown has moved to Buffalo, N. Y., where he is situated in the Research Dept. of the Buffalo Pottery Company.

Kenneth Buck, who has been employed by the Bureau of Standards, Columbus Station recently accepted a position with the Wheeling Tile Company, Wheeling, W. Va.

E. N. Bunting, who has been affiliated with the National Research Council, Washington, D. C. has accepted a position with the Bureau of Standards in Washington.

W. T. Christian has moved from Wellsville, Mo. to DesMoines, Iowa.

A. W. Crownover, of the Maryland Glass Corporation, Mt. Winans, Md. is now associated with the Peerless Glass Co., 701 Vernon Ave., Long Island City, N. Y.

Harry E. Davis has transferred his connections from the Faience Tile Department, Gladding, McBean & Co., to the Federal Terra Cotta Co., Woodbridge, N. J.

S. L. Galpin, who for many years has been connected with the Department of Mining and Geology, Iowa State College, is now affiliated with West Virginia University, Morgantown, W. Va., Department of Geology.

Herbert Goodwin has moved from Niles, Ohio, to Cambridge, Ohio, where he is superintendent of the Globe China Company.

Donald Hagar, formerly of the Mosaic Tile Company, Matawan, N. J. is now connected with the Cambridge Tile Mfg. Company of Covington, Ky.

M. L. Hartmann has resigned as director of Research of the Carborundum Company, Niagara Falls, N. Y. to become technical director of the Celite Products Company, Lompoc, California. Dr. Hartmann is on the Publication Committee of the *Journal of the American Ceramic Society.*

The Livermore Fire Brick Works, Inc., of San Francisco, California has been succeeded by the **W. S. Dickey Clay Mfg. Co.,** Pacific Coast Branch.

Wilfrid Mavor, formerly of Toronto, Canada, has moved his headquarters with the Ferro Enameling Company to Schenectady, N. Y.

Thomas H. Morris is now located with Ball Bros. Co., Muncie, Indiana.

Erwin Sohn is, at the present time, associated with the Pittsburgh Works of the Standard Sanitary Mfg. Company.

G. N. White of Oscar Guttman and Sons, London, England has resumed his membership in the SOCIETY after a lapse of two years.

LOCAL SECTION MEETINGS

Hansen Addresses Pittsburgh Section[1]

At the last regular monthly meeting of the Pittsburgh Section, AMERICAN CERAMIC SOCIETY, January 18, 1927, Mr. J. E. Hansen, Cleveland, O., gave an interesting address on "Effect of Shop Practice on Working Properties of An Enamel." Mr. Hansen ably discussed the difficulties and practices used in working with enamels.

The annual election of officers was also held. The officers elected for the year 1927–1928 are as follows:

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[1] C. H. Geister, *Secy.*

Chairman, Dr. Chas. R. Fettke, 1118 Wightman St., Pittsburgh, Pa.
Vice-Chairman, H. M. Kraner, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.
Treasurer, G. R. Pole, Mellon Institute, Pittsburgh, Pa.
Secretary, C. H. Geister, Mellon Institute, Pittsburgh, Pa.
Councilor, F. W. Walker, Beaver Falls, Pa.

Baltimore-Washington Section[1]

The second meeting of the 1926–27 season of the Baltimore-Washington section of the AMERICAN CERAMIC SOCIETY was held at Hotel Emerson, Baltimore, Md., Saturday evening, December 11, 1926.

After the usual dinner at 6:30 P. M., enjoyed by 29 members, the business of the evening was taken care of. The report of the Committee on By-Laws and Constitution was heard and the proposed By-Laws and Constitution were adopted by unanimous vote.

The suggestion of Chairman A. N. Finn, that the next meeting in Washington in March be devoted to motion pictures on clay mining, glass manufacture, pottery industry, and fireclay industry, was favorably accepted and an interesting meeting is being planned.

The first paper of the evening by H. G. Schurecht of the Bureau of Standards on "Architectural Terra Cotta" dealt particularly with one of the defects met with in the industry, namely, crazing. Two types of crazing were discussed; one apparent in the ware coming from the kiln, the other apparent after the ware had been in service some time. The causes of and means of overcoming these defects were ably presented and points of interest to the enameling industry were discussed.

The second paper, presented by R. R. Fusselbaugh of the Baltimore Enamel and Novelty Co., on "The Observations of Relation of Composition to Ground Coat Defects in Enamels for Steel" covered much experimental work carried on by the author and was clearly demonstrated by actual specimens of enameled sheet showing the various points brought out in the paper. The paper showed that, taking a ground coat enamel giving good results in practice under controlled conditions and varying the ratio of Na_2O to B_2O_3, where the Na_2O was increased and the B_2O_3 decreased the tendency was to get away from blistering and fish scaling but the tendency to rust-spot or copperhead was increased. On the other hand where the Na_2O was decreased and B_2O_3 was increased the tendency was to overcome copperheading and to get into blistering and fish-scaling.

The author used the following enamel as a standard and varied the Na_2O and B_2O_3 as indicated:

	I	II	III
Feldspar		45.4	
SiO_2		15.0	
Na_3AlF_6		7.5	
CoO		.9	
MnO		1.2	
Na_2O	25.0	15.0	5.0
B_2O_3	5.0	15.0	25.0

The paper was widely discussed by the enamelers and was very interesting to all.

The meeting was adjourned to meet in March at the Bureau of Standards.

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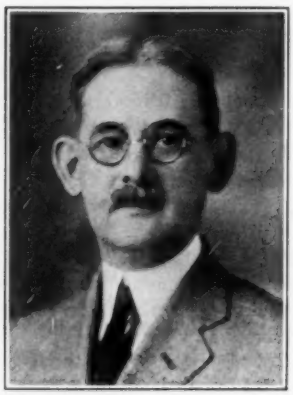
[1]C. B. McComas, *Secy.*

IN MEMORIAM

Charles D. Fraunfelter

Charles D. Fraunfelter was born February 10, 1868, at Savannah, Ohio. At the age of two he moved to Akron, Ohio, where his father was professor in Buchtel College, now Akron University. In 1899, Mr. Fraunfelter moved to Zanesville with the Roseville Pottery Company and remained with that concern for sixteen years. In 1915 he organized a company and bought the Old Ohio Pottery Company, Zanesville, Ohio, which at that time was manufacturing stoneware specialties. That line was produced for only a short period, as soon after that was developed the first and only hard porcelain that had been produced in America. This first line consisted only of laboratory chemical porcelain. Later on, a line of cooking and baking ware was added and as the business developed, white china for decorators and hotel dinnerware for hotels, clubs, restaurants, and dining car service was added.



On October 31, 1923, the Ohio Pottery Company was sold to the Fraunfelter China Company, a Corporation organized under the laws of the State of Maine, operating factories at Zanesville, Ohio and Chesterton, Indiana. Mr. Fraunfelter acted in capacity of president and general manager of the new Company and continued in that capacity until his death. The factory at Chesterton, Indiana was operated for a period of approximately two years, after which time it was decided that the entire efforts would be made on the Zanesville plant alone, and therefore in 1926 sufficient new buildings were erected and various changes made throughout the factory to make it possible for the construction of a tunnel kiln, which would give the Company the same output in the plant as they formerly had with two but under one management. This work was practically completed with the exception of the tunnel kiln at the time of Mr. Fraunfelter's death. He did, however, live long enough to see that his ambition in life had been attained. His one aim was to develop an industry that would grow and prosper and continue to exist as one of the staple industries of the country in years to come. The severe strain of the past few years had quite materially undermined his physical health, and when stricken with pneumonia, he did not have the strength left to carry on the fight.

For the past thirty years Mr. Fraunfelter has been a student of ceramics, and was interested in all phases of the industry, whether or not pertaining to his immediate business. The result of his studies, combined with the practical experience for the past twelve years, made him well posted.

Mr. Fraunfelter is survived by his widow, Mrs. Charles D. Fraunfelter, one son, George E. Fraunfelter, and three grandchildren, all of Zanesville, Ohio.

Mr. Fraunfelter had been a member of the AMERICAN CERAMIC SOCIETY, actively interested in its development, for more than a quarter century.

George Sebring Dies January 5 in City He Founded

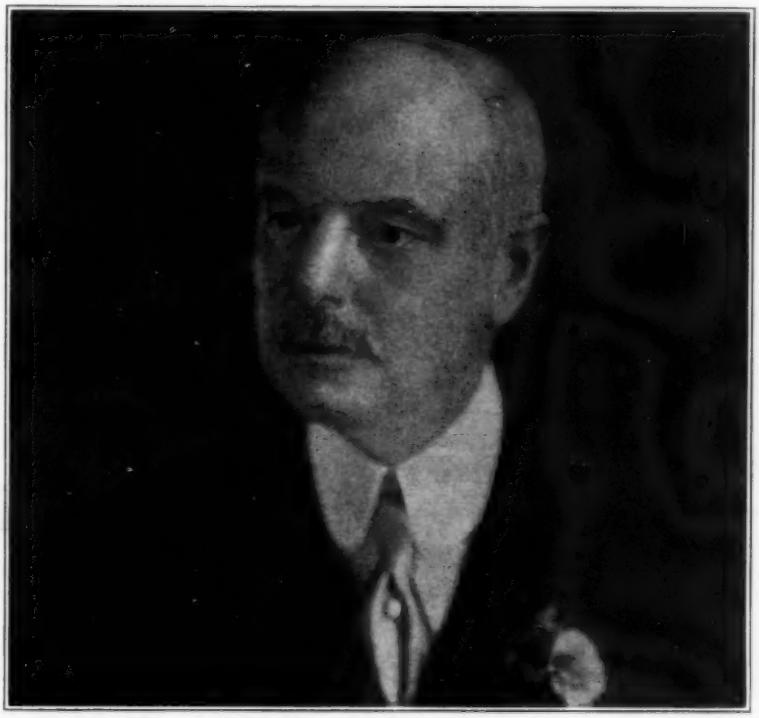
While citizens of Sebring, Fla. and Ohio mourned the death of the man they knew affectionately as "Dad" Sebring, thousands of Floridans recalled the unselfish devotion

of George E. Sebring, who carried the first relief to Moorehaven when the little Lake Okeechobee town was overwhelmed in the September hurricane. A native Ohioan and founder of the two towns which bear his name, Sebring was buried in Sebring, Ohio, where more than 15 years ago he ended a hunting trip with the resolve to build a model community.

Mr. Sebring rose in the business world from a potter's bench to the joint ownership of one of the largest potteries in the world. Mr. Sebring's Company holds a Corporation Membership in the AMERICAN CERAMIC SOCIETY.

Charles Howell Cook

Charles Howell Cook was born near Millstone, N. J. on October 20, 1856. At a very early age Mr. Cook was employed as a clerk in a wholesale grocery business in Trenton,



New Jersey. After a short time he entered the employ of Ott & Brewer, first as a bookkeeper, and later as a traveling man. In 1883 Mr. Cook, together with William S. Hancock, organized The Crescent Pottery Company, which was operated successfully for about ten years, when the business was sold to The Trenton Potteries Company. In 1893 Mr. Cook founded The Cook Pottery Company, and was its active head until October, 1926, when, because of a physical and nervous breakdown, he found it necessary to retire from the active management of the business. He took up his residence with his daughter, Mrs. Carter H. Harrison, Jr., of Winnetka, Illinois.

Contrary to expectations, Mr. Cook's health did not improve with the change of scene, and on December 7, 1926, he died, and was buried on December 10th in Riverview Cemetary at Trenton, New Jersey.

In addition to the operations of his pottery plants Mr. Cook also operated two farms and a large creamery.

As a citizen of Trenton he enjoyed the respect of all who knew him. He served as a Director of the School of Industrial Arts for several years, was President of the United States Potters Association, and also President of the New Jersey Clay Workers Association. It was largely due to Mr. Cook's efforts and influence that the present Ceramic Department of the New Jersey State College was provided with a suitable building.

Mr. Cook had been an active worker in the AMERICAN CERAMIC SOCIETY for many years.

Louis Lees Bentley

Louis Lees Bentley, general manager of the Armstrong Cork Company died recently in Beaver Falls, Pa. Mr. Bentley, who had been a member of the AMERICAN CERAMIC SOCIETY since 1914 was born in 1868. He was graduated from Cornell in the Department of Mechanical Engineering. In 1907 he became identified with the Armstrong Cork Works and until the time of his death continued with that company.

James S. Moore

James S. Moore, manager of the Peerless Glass Company, Long Island City, N. Y. died recently. Mr. Moore had been a member of the SOCIETY since 1924.

NOTES AND NEWS

ANNUAL MEETING OF THE PACIFIC NORTHWEST CLAYWORKERS' ASSOCIATION WITH PACIFIC NORTHWEST BRICK AND TILE ASSOCIATION[1]

Members of the Pacific Northwest Clayworkers' Association and the Pacific Northwest Brick and Tile Association held their Annual Meeting in Seattle, Washington, January 14 and 15. The subject for discussion for the Friday afternoon program was "Sales and Distribution." The following subjects were discussed at the Saturday afternoon meeting:

1. The results of the University's kiln tests of Hoffman and wood-fired round down-draft kilns.

2. Progress report on the freezing tests of brick.
3. Progress report on the scumming of brick walls by mortar materials.
4. Methods of adding barium salts to clays.
5. Chicago common brick clay versus Puget Sound common brick clay.
6. Stoneware products of the Pacific Northwest.
7. Kaolin washing in Eastern Washington and the value to clay refractories.
8. The removal of water from clay slips or suspensions.
9. Cost accounting method for the brick manufacturer. Several papers.
10. Clay mining. Hand method, steam shovel, underground mining, glory hole methods, clam shovel, caving methods. Discussions by several experts.
11. Firing hogged fuel in a continuous chamber brick kiln.

MEETING OF IOWA CLAY PRODUCTS MANUFACTURERS' ASSOCIATION

Members of the Iowa Clay Products Manufacturers' Association will hold their Annual Meeting in the auditorium of Engineering Hall of Iowa State College at Ames, Iowa, February 8, 9, and 10.

At the same time a Short Course designed for plant men will be given under the joint direction of the Department of Ceramic Engineering and the Engineering Extension Department of Iowa State College. The course of study will be planned to help the clay industries of Iowa through the training of their men, both at this short course and later on by work with them in the factories.

SOCIETY OF GLASS TECHNOLOGY

Walter Butterworth, president, presided at a meeting of the Society of Glass Technology held in University College, London, on Wednesday, December 15, 1926. Five papers were presented.

(*a*) **"Further Note on Sillimanite as a Glass Works Refractory."** By W. E. S. Turner. A pot ring made from a mixture of 5 parts of fine, 1 part of medium, and 1 part of coarse sillimanite, with 3 parts of ball clay, was broken in use after doing service for ten weeks in a pot melting a potash-lead oxide-silica glass. The ring showed little sign of attack by the glass.

A sillimanite pot, holding 30 pounds of glass, had been in use, in the Department of Glass Technology at Sheffield, for melting a series of soda-ferric oxide-silica glasses. The pot stood up well under this work, exhibiting no signs of honey-combing. This result was rather remarkable, since sillimanite usually offered little resistance to the attack of ash rich in iron compounds.

Photographs were exhibited of another pot which had been used for 23 successive meltings and had ultimately a porosity of 14 to 15%.

In order to prove the great resistance offered by sillimanite to changes in temperature, photographs were shown of a pot which was allowed to cool in the bottom of a furnace. After some days the furnace was heated again. The pot was still being used for glass melting a month afterwards, the temperature of the last run in it being 1450°.

(*b*) **"Some Corrosion and Erosion Phenomena and Their Bearing on the Macrostructure of Refractories,"** By J. F. Hyslop, R. Gumm and H. Biggs. The importance of the macrostructure of refractories was emphasized in connection with corrosion and erosion phenomena. The use of an indirect method, such as that employed, indicated that the characteristics and grading of grog were factors of considerable moment.

[1] Hewitt Wilson, *Secy.*

Data were given which showed that the disintegration in a solvent of a composite material such as wax loaded with fired clay particles, depending on two factors, (*a*) the density of the solute-rich layer relative to the solvent, and (*b*) the size of the particles. If a light upward flowing layer was formed the material with large particles would be more rapidly broken up than that containing small particles. The reverse holds if a dense downward flowing layer is formed, the finer the particles the more rapid being the corrosion.

Laboratory experiments on clay rods immersed in chosen glasses confirmed the above statements in respect to the corrosion of clay by glass. In a lead glass the clay with the larger grog was more corroded than that with the finer, but in a soda-lime glass the finer material was the more attacked. Consistent with safety in other directions, the evidence indicated that a refractory meant to withstand corrosion by a lead glass should contain as large a fraction of fine grog as possible, whereas one for use with a soda-lime glass, say, should contain the maximum of large grog.

It was also shown that where erosion was the principal factor in the break-up of the refractory the conditions demanded different characteristics in the grog in that the material must hold the maximum of fine particles.

(*c*) **A Note on the X-ray Patterns of Mullite and Sillimanite.** By J. F. Hyslop and H. P. Rooksby. In two former notes it was stated that sillimanite and mullite gave X-ray patterns which could be distinguished, and the object of this further note was to record the data which had been obtained for several alumina-silica materials. By paying attention to the necessary technique, such as the degree of fineness of the powder and the time of exposure to the beam of X-rays, consistent results were obtained. It was concluded that there were, on close inspection, real and consistent differences between the patterns of sillimanite and of the crystalline substance formed in the samples examined. Further, these differences, although small, had been found sufficient for identification, purposes, since they depended upon the relative spacing of the lines and not on differences in intensity which could be caused by preferential orientation of the crystals.

(*d*) **"Note on the Design of Parison Molds."** By S. English. Of the three molds, the ring, parison, and blow molds, ordinarily used in the making of bottles by machines, the parison mold was by far the most difficult to design properly. There was only one feature of a parison mold that could be determined even approximately by a study of the finished bottle it was desired to reproduce, and that was its internal size or glass holding capacity; but even in this respect allowance had to be made for the preliminary blow up which varied from one machine to another, and from one type of bottle to another. For the purpose of parison mold calculations it was convenient to use the volume occupied by 1 ounce of hot glass. Assuming that 1 ounce of glass at 1250°C occupied $\frac{3}{4}$ cubic inch, a gob of glass to form a 24 ounce bottle should have a volume of 18 cubic inches. In regard to the shape of parison molds, the only feature which was recognized as essential, was the absence of sharp corners. The inner surfaces should always be continuous smooth curves.

The primary function of parison molds was to give a preliminary shaping to a quantity of glass, and the molds could only do this efficiently by cooling the glass surface in contact with the mold. It had been found that a heavy-walled mold always kept cooler than a light-walled mold under similar conditions. The thicker mold required less external cooling, and retained its good condition longer than the thinner one; but it was much heavier and in the case of a charge of molds it heated up to the proper working temperature so slowly that a considerable loss of output was entailed. Cast iron appeared to be perfectly satisfactory as a parison-mold material. It was suggested, however, that stainless steel parison molds might be tried in the case of small bottles.

The fifth paper was presented by V. H. Stott, and was entitled, "The Viscous Properties of Glass."

Owing to lack of time the reading of the sixth paper on the agenda was postponed, namely, "The Effect of Cullet on the Melting of Glass" by W. E. S. Turner.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 14–19, 1927	Detroit, Mich.
American Chemical Society	April 11–16, 1927	Richmond, Va.
American Concrete Institute	Feb. 22–24, 1927	Chicago. Ill.
American Concrete Pipe Assn.	Feb. 21–22, 1927	Chicago, Ill.
Amer. Electrotechnical Soc.	April 28–30, 1927	Philadelphia, Pa.
Amer. Foundrymen's Assn.	June 6–9, 1927	Chicago, Ill.
Amer. Gas Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Chem. Engrs.	June 1–4, 1927	Cleveland, Ohio
Amer. Inst. Min. and Met. Engrs.	Feb. 14–17, 1927	New York City
Amer. Soc. Mech. Engrs.	May 23–26, 1927	White Sulphur Springs, W. Va.
Amer. Soc. Steel Treating	Sept. 19–23, 1927	Detroit, Mich.
Amer. Soc. Testing Materials	June 20–24, 1927	French Lick, Ind.
Amer. Zinc Institute	April 18–19, 1927	Montreal, Canada
Assn. Chem. Equipment Mfrs.	Sept., 1927	New York City
Can. Natl. Clay Prod. Assn.	Feb. 8–9, 1927	Toronto, Canada
Common Brick Mfrs. Assn.	Feb. 21–26, 1927	Chicago, Ill.
Glass Container Assn.	April or May, 1927	?
Hollow Bldg. Tile Assn.	Feb. 9–11, 1927	Chicago, Ill.
Manufacturing Chemists Assn.	June 2, 1927	New York City
Natl. Academy of Sciences	April 25–27, 1927	Washington, D.C.
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 8, 1927	Pittsburgh, Pa.
Natl. Assn. of Stove Mfrs.	May 11–12, 1927	New York City
Natl. Safety Council	Sept. 26–30, 1927	Chicago, Ill.
Natural Gas Assn. of Amer.	May 17–19, 1927	Cincinnati, Ohio
Sand-Lime Brick Assn.	Feb. 1–3, 1927	Detroit, Mich.
Society of Glass Technology (Eng.)	Feb. 16, 1927	Sheffield, England
Stained Glass Assn. of Amer.	June 27, 1927	St. Louis, Mo.

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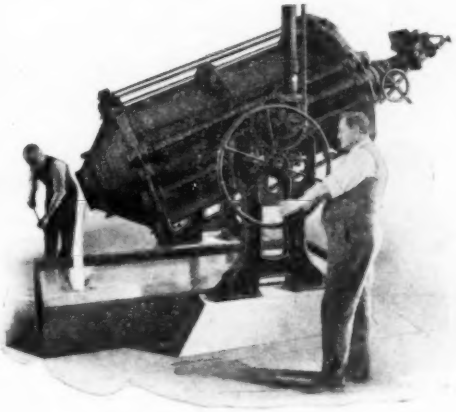

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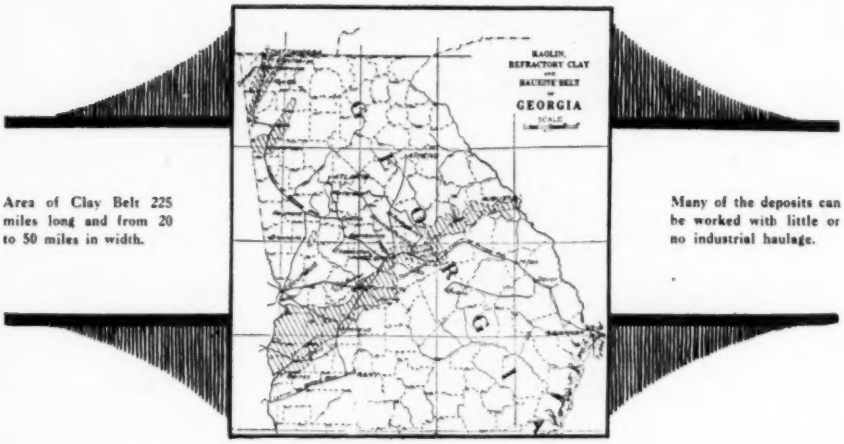
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Kaolin and Refractory Clay Deposits in Wilkinson Co., Ga.
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Tin Sheet Steel	*6 to 10 years*	*10 years*
Copper	*10 to 20 years*	*No limit*

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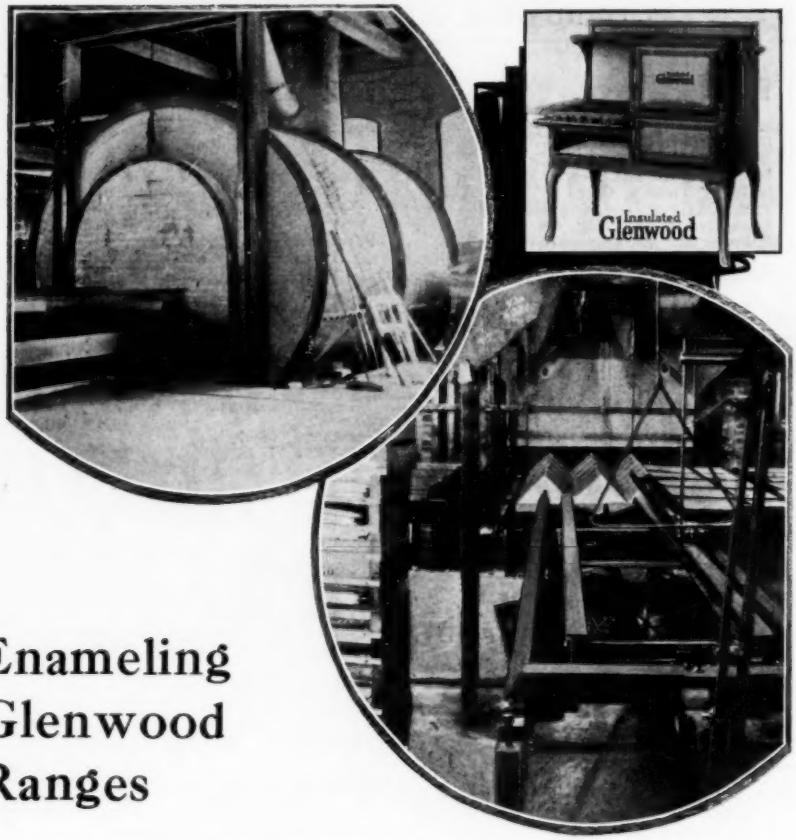

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A CORRECTION

In a recent issue of the Journal, it was stated that the Boric Acid of the American Potash & Chemical Corp. was 95% pure. It should have read 99.5% pure. See their advertisement on page 33.

CERAMIC BREVITIES

The Seaboard Fuel Corp., with main offices at 260 S. Broad Street, Philadelphia, Pa., announce the opening of a branch office in Room 305 Broad Street National Bank Bldg., Trenton, N. J.

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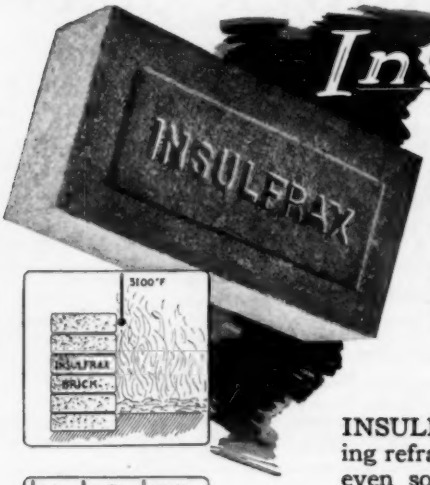

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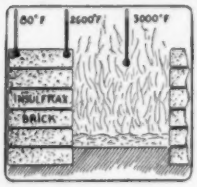

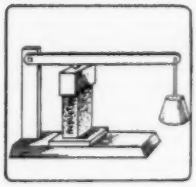

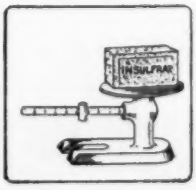

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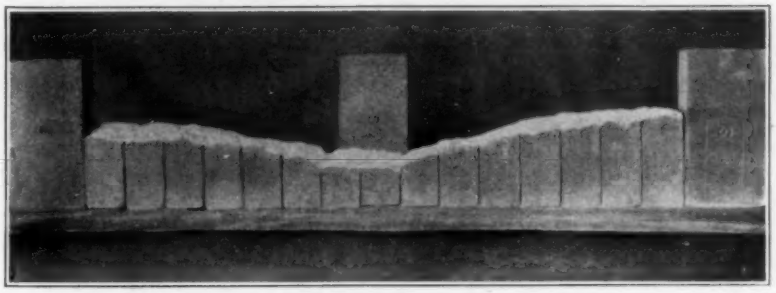

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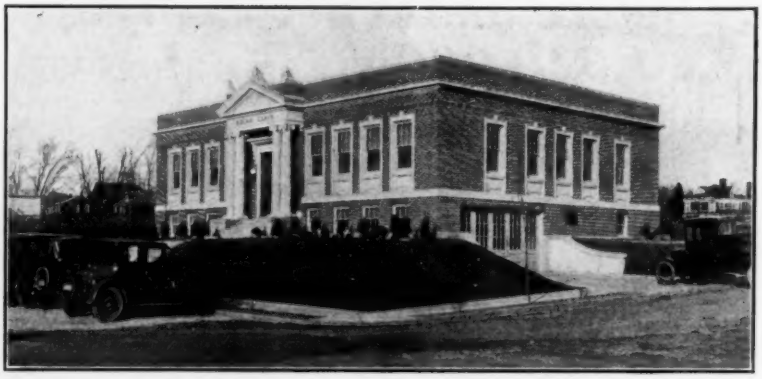

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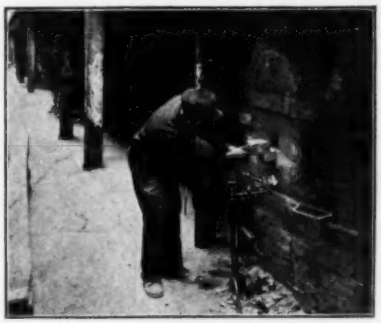

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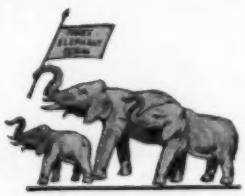

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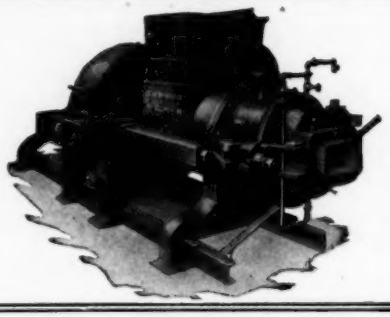

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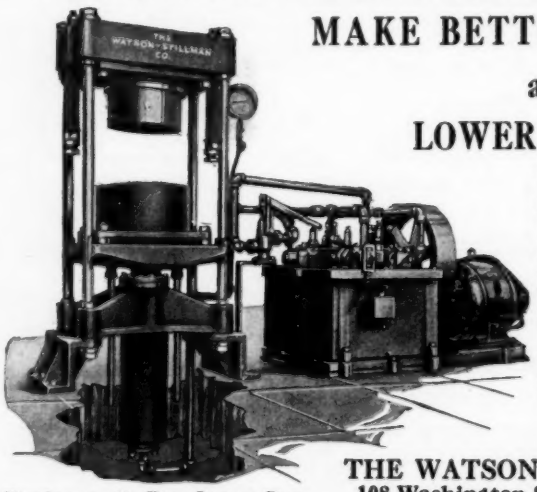

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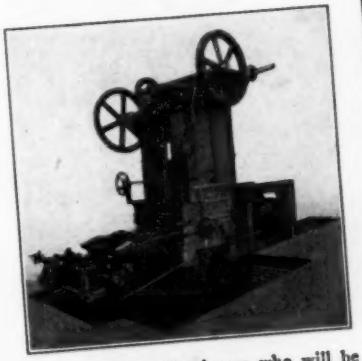

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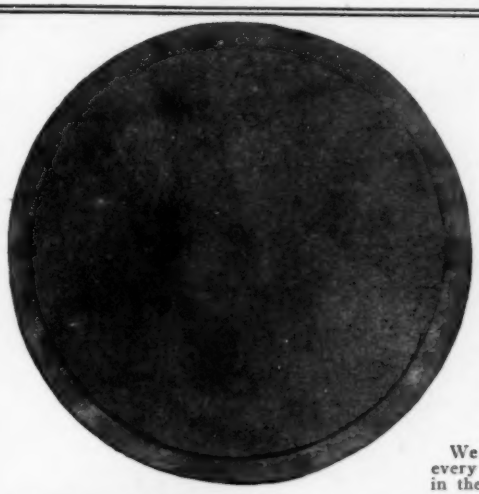

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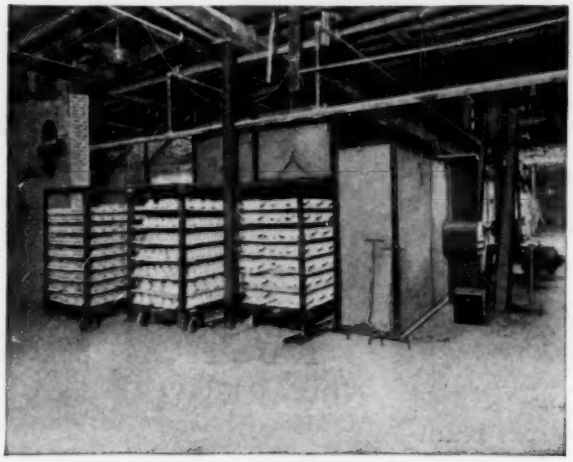

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Journal
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BIBLIOGRAPHY OF LITERATURE ON REFRACTORIES

The third of a series of bibliographies compiled by members of the Refractories Division, American Ceramic Society.

Entered as second class matter at the post office at Menasha, Wis. Acceptance for mailing at special rate of postage provided for in the act of February 28, 1925, embodied in paragraph 4, Section 412 P. L. and R. Authorized January 29, 1926.

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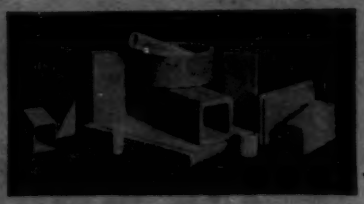

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The Secretary will be pleased to supply further information concerning the Institute's activities and publications, as well as information concerning membership in the organization.

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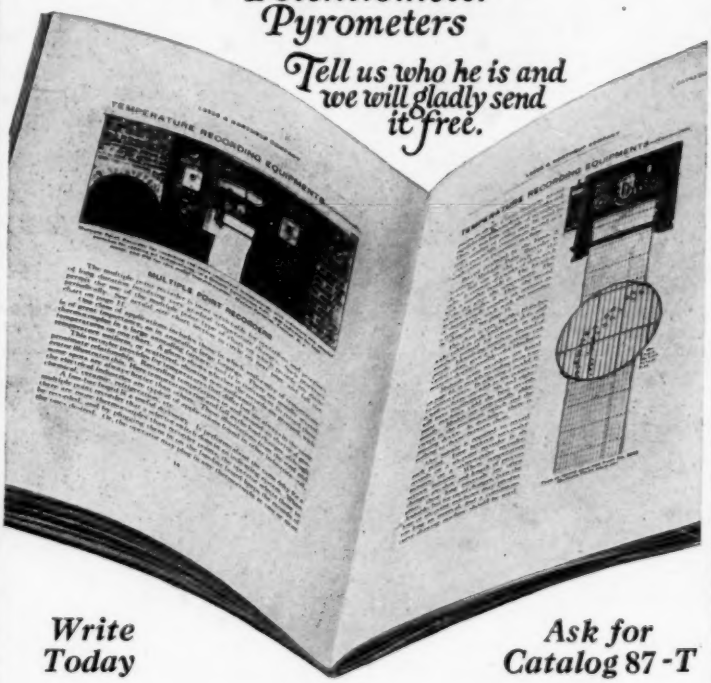

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N. BRADLEY, Gladding McBean & Co., 621 S. Hope St., Los Angeles, Calif.
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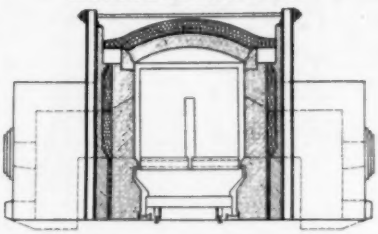

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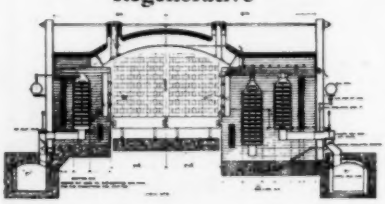

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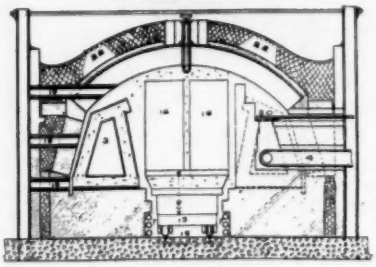

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Preface

THIS is the third of a series of Bibliographies compiled by members of the Refractories Division of the AMERICAN CERAMIC SOCIETY.

Bibliography of the literature on Magnesite Refractories issued in 1924 was compiled by R. M. Howe, H. G. Schurecht, R. T. Stull, J. Spotts McDowell, E. E. Ayars, and F. A. Harvey.

References to literature on magnesite are brought up to 1926 in the present volume without duplicating any of those in the special *Magnesite Bibliography.*

Bibliography of the literature on *Silica Refractories* issued in 1924 was compiled by James T. Robson who at that time was Professor in Ceramic Engneering at Ohio State University. Dr. Robson compiled that *Bibliography* for use in lectures on refractories.

References to literature on *Silica Refractories* in the present volume brings up to 1926 the references without duplicating any of those compiled by Dr. Robson.

This, the third in the series, is general in character and is in chapters under heading of (1) General, (2) Fire Clay, (3) Aluminous, (4) Magnesia, (5) Dolomite, (6) Chrome, (7) Silica, (8) Silicon Carbide, (9) Fused Silica, (10) Graphite, (11) Special (Refractories), (12) Special (Uses), (13) Cement, Mortars, and Bonding Materials.

Special attention is drawn to the persons who compiled and those who have underwritten the issuance of this *Bibliography* and to those firms who have taken advertising space. The labor and expense of compiling and publishing biblographies are large. To those who have made possible this *Bibliography* and the two others previously issued there is due the appreciation and thanks of both the producer and the user of refractories.

ACKNOWLEDGMENT

The preparation of this bibliography has been in charge of the members of the staff of the Department of Ceramic Engineering, University of Illinois, who originated the method of classification and gathered the greater part of the material. This has been supplemented by a number of titles which had been gathered by a committee of the Refractories Division of the AMERICAN CERAMIC SOCIETY.

This work has been made possible by funds provided chiefly by certain public utility companies of Northern Illinois, namely: The Commonwealth Edison Company; Peoples Gas Light and Coke Company; Public Service Company of Northern Illinois; Middle West Utilities Company; Chicago Rapid Transit Company and Chicago North Shore and Milwaukee Railroad Company, and also by the AMERICAN CERAMIC SOCIETY. Those who have collaborated in this work were: Of the department of Ceramic Engineering, University of Illinois: Professor C. W. Parmelee, Professor R. K. Hursh and T. N. McVay with the assistance of E. P. Wright, W. H. Pfeiffer, and G. G. Grogan. Of the AMERICAN CERAMIC SOCIETY C. J. West, R. F. Ferguson, R. M. Howe, M. C. Booze, L. V. Reese, J. S. McDowell, and F. A. Harvey, Chairman.

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GENERAL

1. Further experiments for determining the fusibility of fire clays.

H. O. HOFFMAN. *Trans. Amer. Inst. Min. Eng.*, **25**, 3–17 (1895).—A good article on Seger cones and their use.

2. Grog materials, their properties and testing in zinc furnaces.

OTTO MUHLHAUSER. *Zeit. f. angew. Chem.*, **16**, 321 (1903); *Trans. Ceram. Soc.* (Eng.), **16**, 43A (1917).—Gives manufacture and composition of block for zinc furnace walls. Porosity and density determinations and the chemical compounds are given. Analysis of dust particles from zinc furnace is given. A stone which had been in use for 75 months was covered by a glaze of 2 layers. The exposed layer was dark brown while the under layer was a grayish white. Microscopic examinations showed minute cavities. The stone had a waxy luster and was sintered throughout. The stone shattered on breaking and was extremely hard. The chemical compositions of the stone and glaze are given. The density of the piece had increased by use.

3. The refractoriness of New Jersey fire brick.

H. RIES. *Trans. Amer. Ceram. Soc.*, **6**, 141 (1904).

4. Properties of refractory materials.

S. WOLOGDINE. *Bull. Soc. d'encouragement*, **111**, 879–942 (1909); *Sci. Abs.*, **12A**, 458 (1909).—A lengthy table of results is given of the conductivity for heat, porosity, and permeability to gases of numerous refractory materials. Analyses are given in certain cases. The types dealt with are mixtures for refractory products, service bricks, and terra cotta. With exceptions there is a roughly inverse relation between porosity and conductivity.

5. Refractory materials for crucibles, furnace linings, etc.

FREDRICK GROSSMAN. U.S. 951,113, March 8, 1910; *C. A.*, **4**, 1532 (1910).—Materials used for and method of preparing mixture and firing temperature are given.

6. Chemical and physical changes in clay due to heat.

J. M. KNOTE. *Trans. Amer. Ceram. Soc.*, **12**, 226–64 (1910).—In most cases non-plastic clays had greater density from 450–1000° than plastic clays. Try effect of acids, bases, etc., on solvency. Make sand lime brick tests. Volume changes of clays. Theory is that breaking up of kaolinite cannot explain specific gravity increase at 950°.

Density	T	Density	T
2.60	raw	2.54	750
2.62	450	2.56	800
2.58	500	2.58	850
2.48	550	2.59	900
2.49	600	2.70	950
2.51	650	2.70	1000
2.52	700		

7. Metallurgical refractories.

K. SEAVER. *Iron Age*, **85**, 17, 1001–12 (1910); *Min. and Metal*, **1**, 4, 134 (1910).—A review of the essential qualities and of the uses of metallurgical refractories.

8. Flow of heat through furnace walls.

ANON. *Amer. Machinist*, p. 742, April 20, 1911.—An editorial which refers to a Bulletin published by the Bureau of Mines, Department of the Interior, under the title

"Flow of Heat through Furnace Walls" prepared by W. T. Ray and Henry Kreisinger, takes up the subject in a concise and comprehensive manner. The conclusions of the paper are summarized as follows: In furnace construction a solid wall is a better heat insulator than a wall of the same thickness containing air space. This statement is particularly true if the air space is close to the furnace side of the wall, and if the furnace is operated at high temperatures. Loose, crushed brick or ash offers higher resistance to heat flow through walls than an air space, and prevents air leakage, which is an important feature deserving consideration.

9. The future of coke-oven bricks.

ANON. *Brit. Clayworker*, **19**, 260(1911); *C. A.*, **5**, 1982(1911).—Failure is often caused by alkaline constituents of fuel ash. Schrieber suggests that slags from the fuel enter the brick through the minute cracks and fissures in the surface and form strata which are more highly vitrified than the remainder of the material and are therefore more sensitive to changes in temperature and break down more readily.

10. Defects in refractory brick.

J. C. BAILAR. *Met. Chem. Eng.*, **8**, 517; *C. A.* **5**, 580(1911).—Defects in manufacturing: (1) Improper preparation. (2) Superannuated methods of manufacture. (3) Firing at too low a temperature. (4) Failure to provide proper shapes in molding necessitating grinding or cutting. (5) Forcing clay out of the machine in such a way as to cause little cracks in the corners.

11. Refractory materials.

L. B. MILLER. *Proc. 7th Int'l. Cong. Appl. Chem.*, **2**, 95–98; *C. A.*, **5**, 2538(1911).—The faults of refractories which cause their destruction are: impure raw materials, use of inapplicable methods of manufacturing, firing at temperatures below those at which the refractories are used. The defects are: too low fusion point, lack of constancy of volume during use, insufficient density, openness of structure allowing gaseous or liquid agents to penetrate and attack the body, insufficient resistance to abrasion and impact, and too great a sensibility to temperature changes. All these defects can be largely or entirely overcome by the proper selection of materials.

12. The melting point of fire brick.

ANON. *Jour. Frank. Inst.*, **174** [2], 227(1912).—Notes from the Bureau of Standards by C. W. Kanolt on the melting point of fire brick contains a table of melting points of refractory fire brick which will prove valuable and interesting.

Material	No. of Samples	Melting Point °C
Fireclay brick	41	1555–1725 mean 1649
Bauxite brick	8	1565–1785
Silica brick	3	1700–1705
Chromite brick	1	2050
Magnesia brick	1	2165
Kaolin	3	1735–1740
Bauxite	1	1820
Bauxite clay	1	1795
Chromite	1	2180
Pure alumina	–	2010
Pure silica	–	1750

13. The selection and use of refractory materials.

C. DEBLOTTERFIERRE. *Brit. Clayworker*, **21** (1912); *Brickbuilder*, 45–47(1912).—The vitrification range of refractories is far more important than the fusion point usually

given. In manufacture the material should be screened into grades and these properly proportioned. In a mix of plastic and non-plastic materials the volume of the larger particles should be double that of the plastic material and the fine non-plastic particles.

14. Attack of slagging materials on grog.

H. HIRSCH. *Berichte*, 32. (Ordentliche Manptversammlung des Vereins deutscher Fabriken feuerfester Produkte E. V.) (1912); *Trans. Ceram. Soc.* (Eng.), **17**, 60A, 84 (1918).—Body mixtures of 50% grog were tested at cone 14 with cupola slags, Portland cement, and marble. With the cupola slag the action increased with the amount of water used in making the test piece. Cement formed a glassy slag. Analysis given. Marble gave same results as cement.

15. The action of slags upon fire brick.

M. HIRSCH. *Sprechsaal*, **45**, 213 (1912); *C. A.*, **6**, 3320 (1912).—A description of the slagging action of various substances upon fire brick is given.

16. Firing pulverized coal in smelters and furnaces.

L. S. HUGHES. *Min. Eng. World*, **36**, 851 (1912); *Jour. Soc. Chem. Ind.*, **31**, 525; *C. A.*, **7**, 1277 (1913).—Causes a slag to form on the grate bars, crown sheet, and walls of the firebox due to the action of the FeO and SiO_2. Pulverized limestone introduced into the pulverized coal changed the character of the ash from a sticky shower to a dry, powdery material which did not clinker or cohere to the brick.

17. Resistance of refractory ware against abrupt changes of temperature.

PAUL WINDSZUS. *Tonind. Ztg.*, **36**, 1656 (1912); *Met. Chem. Eng.*, **10**, 662 (1912).—Increasing the size of the grog particles and the proportion of grog to binding clay results in more resistance to sudden temperature changes. The temperature of the experiments (900–1000°) was too low, however, to give results of practical significance. It is suggested that some standard rules be established for representing capacities to resist heat changes.

18. Testing fire brick for use in coke ovens.

COPPÉE. *Iron and Coal Trades Rev.*, Sept. 26, 1913; *Eng. Min. Jour.*, Nov. 1, 1923.—An illustrated description is given of the apparatus used by Baron Coppée for measuring the expansion of fire bricks. The apparatus consists of a furnace for heating the bricks, a cathetometer for observing the expansion and a standard meter scale of invar metal divided into millimeters for measuring the expansion. The cathetometer is of the horizontal type composed of a metal bar mounted on a central pivot so as to rotate in a true horizontal plane. Two sighting telescopes fitted with vertical and horizontal cross wires are mounted on the bar. One telescope has an adjustable vertical cross wire controlled by a micrometer screw. By means of this, observations of the expansion at any temperature can be made by sighting on cuts previously made in the face of the brick.

19. Mineralogical examination of clays.

W. J. MCCAUGHEY. *Trans. Amer. Ceram. Soc.*, **15**, 322–27 (1913).—Gives technique and possible uses.

20. Forming and repairing refractory furnace linings.

B. E. ELDRED. U. S. 1,091,567, March 31, 1914; *C. A.*, **8**, 1861 (1914).—A mixture of fire clay, MgO, ganister or dolomitic lime and tar is forced against the walls by means of a jet of combustion gases.

21. The testing of refractories.

M. GARY. *Feuerungstechnik*, **2**, 178–80, 199–203; *C. A.*, **8**, 3226 (1914).—Gives methods of testing fire brick for: (1) volume change upon repeated firing, (2) expansion

and contraction at different temperatures, (3) heat conductivity, (4) melting point, (5) effects of slag at high temperatures, (6) compressive strength in heated condition, and (7) gas penetrability.

22. Refractory materials in gas works.

T. HOLGATE. *Trans. Ceram. Soc.* (Eng.), **13,** 20A(1914); *Jour. Gas Lighting,* **123** [2618], 169–70.

23. Refractory materials.

G. RIGG. *Jour. Soc. Chem. Ind.*, **33,** 619–26; *C. A.*, **8,** 3225(1914).—Gives method of testing clay refractories for: (1) refractoriness, (2) grain and compactness, (3) firing, (4) porosity, (5) resistance to penetration, corrosion and chemical change in general, (6) truth of surface dimensions, and (7) conductivity.

24. The preparation of refractory bodies for temperatures over 2000° in furnaces with reducing atmospheres.

OTTO RUFF. *Forschungsarbeiten Gebiete des Ingenieurwesens* (1914), No. 147, 31 pp.; *Ceram. Abs.*, **1,** 233(1922).—The only oxides or furnace linings which are sufficiently high melting, nonvolatile and resistant at 2000° to the reducing atmosphere of a carbon resistor are BeO, MgO, and ZrO_2.

25. Fire clay vs. silica brick for retort settings.

ANON. *Jour. Gas Lighting,* **126** [2660], 345–46; *Trans. Ceram. Soc.* (Eng.), **18,** 109A(1915).

26. Refractory materials; their definition and tests.

ANON. *Ceramique,* **17,** 202–4; *C. A.*, **9,** 1675(1915).—Gives method of testing for: (1) melting point, (2) volume change measurement under conditions of use, (3) resistance to action of basic or other agents such as lime, cement, magnesia, clinker and corrosive gases.

27. Deterioration of refractory materials.

H. B. CRONSHAW. *Iron and Steel Inst.*, Carnegie Scholarship Memoirs, **7,** 18(1915); *Trans. Ceram. Soc.* (Eng.), **16,** 65A(1917).—(1) The cause and effects of destruction of refractory materials installed in the various parts of any particular type of furnace. (2) The possibility of arranging those factors in order to their relative importance as destructive agents. (3) The extent to which their effects can be reduced either by eliminating the agents themselves or by selecting bricks with properties best adapted to withstand the agents in question. (4) How far the brick manufacturer can produce specified properties in his brick. The above gives the aspect of the article. Steel furnaces, port blocks, and regenerators are considered extensively. The article gives a thorough analysis of the conditions prevalent and the effect upon the refractories.

28. Fire brick for boiler settings.

W. H. HEISEL. *Mech. Eng.*, **36,** 47–49(1915); *Sci. Abs.*, **18B,** 391(1915).—The development in the manufacture of fire brick has not kept pace with the increase of severity of service. In fact the capacity of most stoker-fired furnaces is limited by the refractoriness of the fire brick. Other materials used are silica, chrome, bauxite, and magnesite. Silica bricks spall and are readily attacked by the basic ash. Other properties of the refractories such as expansion, effect of fluxes, conductivity, and spalling are discussed. The proper building of furnace arches is also discussed.

29. Theory of the origin of clays.

W. STOUT. *Trans. Amer. Ceram. Soc.*, **17,** 557–91(1915).—A discussion as to the close relationship existing between coal and clay, the manner of formation, and the areas in which they are found.

30. General discussion on refractory materials.

ANON. *Proc. Faraday Soc.*, Dec., 1916.

31. Refractory materials and salty coals.

J. W. COBB. *Jour. Gas Lighting*, **133**, 684–88; *Gas World*, **64** [1654], 11–14 (1916); *C. A.*, **10**, 1703 (1916).—NaCl vapors penetrate into the brick causing a rapid deterioration, also a physical change in coefficient of expansion.

32. Refractory materials.

R. HADFIELD. *Trans. Faraday Soc.*, **2** (1916).—Zirconia believed to be one of most importance in future. Magnesite found useful for nozzle for steel ladles.

33. Suitable fire bricks.

M. KAMPFFER. *Tonind. Ztg.*, **41**, 536 (1916); *Trans. Ceram. Soc.* (Eng.), **20**, 28A (1921).—K. considers the fire brick should not be expected to withstand the action of cinders on varying composition. Composition of two coal cinders are given and their effect on fire brick.

34. Selecting materials for the foundry.

W. H. KELLEY. *Chem. News*, **113**, 171–73 (1916).—(1) General rule (all else being equal) the more SiO_2 the less refractory a clay. (2) Dense brick for slag line; more porous in arches to stand temperature changes better. (3) To stand fire use hard-fired, fine-ground brick, medium-fired coarse-ground to prevent spalling (therefore, best for roofs). (4) Bauxite brick to overcome scurfing action of slag. (5) For brass furnaces a brick of coarse grind and hard fire stands action of fused coke and oil deposits best. (6) Steel converters use SiO_2 brick or the same lined with ganister. Crucible steel melting furnaces use SiO_2 brick in melting zone—life is 36–50 months in contrast to 4 or 6 with clay. Cupolas, hard, dense, tough, refractory brick to stand gases above, coarse ground and light brick for bungs where temperature changes.

35. Failure of refractory materials.

ANON. *Brick Pottery Trades Jour.*, **25**, 155 (1917); *Trans. Ceram. Soc.* (Eng.), **16**, 45A (1917).—Three specific causes are discussed: (1) Thick joints. (2) The use of brick cut roughly to shape instead of specially made shapes. (3) The use of excessively large blocks.

36. Refractory materials and salty coals.

ANON. *Ceramique*, **20**, 61, 179 (1917); *Trans. Ceram. Soc.* (Eng.), **18**, 86A (1919).—The reason for the corrosion of refractory brick by salts in coke-oven practice is the low temperature maintained. If the temperature was raised to above 1200°C and the salt introduced it would form a glaze which would act as a protective coating. However the salt is introduced with the coal below 1200° and it penetrates and corrodes the brick. This was proved by experiment. The deposition of carbon and reduction of iron are factors in the corrosion.

37. New processes of manufacturing fire clay and similar articles.

B. J. ALLEN. *Trans. Ceram. Soc.* (Eng.), **16**, 134 (1917); *ibid.*, **17**, 133A (1918).—A description of casting processes in which plaster molds are used in conjunction with vacuum chambers, and also with an electric current. In the vacuum process the entire mold is placed in the vacuum except the mouth which remains open in order that the slip might be under atmospheric pressure. In the electric process the body is deposited on the mold by the electric current and the water is repelled from the mold so that it collects in the center of the mold from where it is withdrawn. Both methods have been used successfully (in the laboratory) for fire clay and pottery. Plumbago and flint have been deposited successfully by the electric current method.

38. American Ceramic Society, presidential address.

L. E. BARRINGER. *Trans. Amer. Ceram. Soc.*, **19,** 69–82 (1917).—A recommendation for increased activity in educational work, defining of standard methods, etc.

39. Refractory materials.

A. V. BLEININGER. *Brick*, **51,** 945 (1917); *Trans. Ceram. Soc.* (Eng.), **18,** 94A (1919).—In firing silica bricks the lime bond forms a monocalcium silicate and the quartz is transformed into cristobalite. Bauxite has a high shrinkage on heating and contracts under pressure at furnace temperature. Reference is also made to magnesite, carbon refractories, pure fused magnesia or alumina, zirconia, spinel, etc.

40. Deterioration of refractory materials.

H. B. CRONSHAW. *Trans. Faraday Soc.*, **12,** 153 (1917); *Trans. Ceram. Soc.* (Eng.), **16,** 71A (1917).—The materials concerned are those used in the iron and steel industry. Abrasion and differential movements assist in the general deterioration of the brick-work, but their importance in normal cases should not be overestimated. A much more important factor is fluxation. An analysis of the conditions existing within the open hearth, regenerators, blast furnaces, and cupolas is given. Within the body of the open hearth and along the sides of the passages through the blocks, the main cause of deterioration is the slagging effect of the basic dust derived from the charges, etc., and of the slag particles shot up from the melt at time of violent ebullition, and the vaporized compounds. At the end portions of the roof very high temperature abrasive action and the sweeping away of the slag to expose fresh surfaces for fluxation are the chief physical influences operating. In the central parts of the roof, differential movements and strains in the brick-work are relieved by fissuring and a falling away of large and small fragments. With siliceous walls, fissures, by facilitating penetration of slags, promote internal fluxation. With magnesia walls, deterioration practically entirely results from shrinkage.

41. Standardization of refractory materials.

H. B. CRONSHAW. *Trans. Faraday Soc.*, **12,** 166 (1917); *Trans. Ceram. Soc.* (Eng.), **16,** 72A (1917).—Suggestions offered for testing and examining refractories for the iron and steel industries and specifications suggested. The use of the microscope is recommended for fast examination and as a check on chemical analysis and physical tests. Suggested the determination of permeability by immersing half of a brick in a tank of molten slag and comparing its porosity after cooling with the original.

42. Refractory materials.

W. DONALD. *Trans. Faraday Soc.*, **12,** 136 (1917); *Trans. Ceram. Soc.* (Eng.), **16,** 88A (1917).—Magnesite bricks are used in basic steel furnaces to form the foundations and are generally lined in England with about 14 inches of dolomite. This dolomite often boils with the metal and has a destructive effect upon the magnesite brick. The magnesite cement largely used in the U. S. was tried but without success. Elsewhere it has been found that Austrian magnesite mixed with about 20% basic slag, gave a satisfactory cement.

43. Refractories linings and materials.

J. W. HANLMAN. *Blast Fur. and Steel Plant.*, **5,** 159 (1917); *Trans. Ceram. Soc.* (Eng.), **17,** 125A (1918).—A discussion of the properties of the refractories used and the correct refractories for use in the iron ladle, basic and acid converters, and furnaces and cupolas.

44. Work of Geological Survey on refractory materials.

J. A. HOWE AND A. STRAHAN. *Trans. Faraday Soc.*, **12,** 159–62 (1917).—A special report is soon to be issued on the raw materials for refractories in Great Britain. The

samples are about all collected and the data recorded. The testing is under way. The report will contain geological data and fairly complete chemical and physical tests for all refractory raw materials in Great Britain.

45. Manufacture of silica bricks.

H. LE CHATELIER AND B. BOGITCH. *Compt. rend.*, **165,** 742 (1917); *Trans. Ceram. Soc.* (Eng.), **18,** 122A (1919).—The size of grain should not exceed 0.5 cm. The use of impalpable quartz instead of fine quartz particles less than 0.1 minimum produced a great increase in mechanical strength at furnace temperatures. Recommends 75% coarse quartz, 2% CaO, and 25% impalpable quartz.

46. Texture of fire bricks.

J. W. MELLOR. *Trans. Ceram. Soc.* (Eng.), **16,** 40 (1917); *ibid.*, **16,** 83A (1917).—A comprehensive study of the effect of grain size and grog. After-expansion and contraction are considered. Hand made vs. machine made brick are discussed. The action of the fluxes during firing of silica and fire brick, use of the chemical analysis, coarse-grained fire brick, fine-grained fire brick and the applications or uses of silica and fire brick are discussed.

47. Discussion on the fine grinding of refractory materials before testing.

R. J. MONTGOMERY. *Trans. Amer. Ceram. Soc.*, **19,** 534 (1917); *Trans. Ceram. Soc.* (Eng.), **17,** 72 (1918).—The softening point of the silica-alumina eutectic was varied from cone 31 to cone 26½ by finer grinding of the silica and clay constituents. In prolonged use this mixture would slowly sinter and fuse at cone 26½ regardless of the original grinding. Cites example where SiO_2 brick have been in use for 9 years in a coke oven and they and the cement were still in good condition.

48. The firing properties of some American refractory clays.

H. G. SCHURECHT. *Trans. Amer. Ceram. Soc.*, **19,** 248 (1917).

49. Refractory materials.

T. TURNER. *Trans. Faraday Soc.*, **12,** 99 (1917); *Trans. Ceram. Soc.* (Eng.), **16,** 86A (1917).—All substances conduct heat at approximately the same rate, and it is the porosity which to a great extent regulates the conductivity of the clay. The packing of the particles regulates the porosity and to some extent the fusibility. Round particles of different diameters give the closest packing.

50. Salt corrosion of coke-oven walls.

ANON. *Gas World*, **68,** 1750, 20–21 (1918); *C. A.*, **12,** 1116 (1918).—80–90% of salt on the brick is NaCl. Can be eliminated by the use of SiO_2 (90%) refractories.

51. Size and quality of fire brick.

ANON. *Iron and Steel Inst.* (preprint) (1918); *Trans. Ceram. Soc.* (Eng.), **17,** 113A (1918).—Results from inquiries on blast furnace practice concerning thickness of walls and quality of refractories used in different parts of the blast furnaces. Five firms used hard-fired medium quality brick throughout, while 11 used best quality for hearth and bosh, and lower quality but hard-fired brick in the top of the furnace where the temperature is lower and erosion greater. The thickness of the linings varied considerably.

52. Tentative tests for slagging action of refractory materials.

ANON. *Proc. A.S.T.M.*, **18,** 578–79 (1918); *C. A.*, **13,** 777 (1919).—Description of the test for the action of slag on refractories is given.

53. Determination of crushing strength of refractory materials.

A. BIGOT. *Chimie et Ind.*, **1,** 723–26 (1918); *C. A.*, **13,** 1003 (1919).—Two general classes of material were formed: (1) Those showing a decided maximum in the strength curve at about 1000° including SiO_2, clay, bauxite, and SiC mixtures. (2) Those showing no maximum at 1000° including MgO, chrome, etc. Strength curves given.

54. Recent developments in ceramics.

A. V. BLEININGER. *Chem. Met. Eng.*, **19,** 467–70 (1918); *Jour. Ind. Eng. Chem.*, **10,** 844–47 (1918).—Refers to some refractories.

55. Some properties of refractory materials.

O. L. KOWALKE. *Gas. Jour.*, **142,** 248 (1918); *C. A.*, **12,** 1693 (1918).—Gives some physical and chemical properties of fireclay and silica brick and the changes of quartz upon firing. Coarse-grained fire brick is more resistant to cracking under sudden temperature changes, but has a lower crushing strength when cold and is less resistive to abrasion, corrosion, or the cutting action of flame. Silica brick must be fired above 1470° to avoid residual expansion.

56. Refractory materials.

J. P. LEATHER. *Gas World*, **68,** 339 (1918); *Trans. Ceram. Soc.* (Eng.), **18,** 109A (1919); *C. A.*, **12,** 1824 (1918).—A discussion of refractory materials from a gas engineer's point of view.

57. Refractory materials in gas works.

J. P. LEATHER. *Gas. Jour.*, **142,** 333 (1918); *Trans. Ceram. Soc.* (Eng.), **18,** 110A (1919); cf. *Trans. Ceram. Soc.* (Eng.), **17,** 244 (1918).—The properties of a refractory which are desirable for use in gas works are discussed. The quality of the refractory is based on: capacity to resist deformation; size of the pieces should not have a permanent change in size; material should not be affected by dust or slag; crushing strength; conductivity and porosity.

58. The standardization of tests for refractory materials.

J. W. MELLOR. *Engineering*, **106,** 540–42, 569–72 (1918); *Trans. Ceram. Soc.* (Eng.), **17,** 300–330 (1918); *C. A.*, **13,** 776 (1919).—Detailed discussion of: (1) Analysis of fire clays, etc. (2) Analysis of dolomite and magnesite. (3) Identification of forms of SiO_2 in brick. (4) Porosity, absorption. (5) Shrinkage in drying and firing. (6) Tensile strength of dried clay. (7) After-contraction or expansion. (8) Normal refractories. (9) Load test. (10) Thermal expansion. (11) Crushing strength cold.

59. Bonding strength of clays between normal temperature and red heat.

C. W. SAXE AND O. S. BUCKNER. *Jour. Amer. Ceram. Soc.*, **1,** 113–33 (1918); *C. A.*, **12,** 2118 (1918).—Ten typical clays were tested. Briquettes were made from 25% clay and 75% alundum. Tensile strengths were determined after drying under various conditions and while heated to various temperatures. The difference between perfect drying and factory drying conditions was found to affect different clays differently. The strength of clays in a hot condition between 110°C and red heat is considerably lower than that at 110°C.

60. Crushing strength of fire brick.

ANON. *C. A.*, **13** [2], 1913 (1919).—*Chemical Abstracts* gives a complete abstract of Refractory Materials Committee.

61. Refractory materials used in coke-oven construction.

ANON. *Gas World*, **71,** [1837], 21–24 (1919); *C. A.*, **14,** 463 (1920).—Chemical comparisons of several bricks are given and some of the mechanical properties are discussed.

62. Provisional specifications for glass refractories.

(The Refractories Research and Specifications Committee of the Council.) *Jour. Soc. Glass Tech.*, **3**, 3–14 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 579 (1919).—Specifications and chemical compositions are given for tank blocks; silica brick; silica cement; raw clays and grog; bond clays; and base clays. Mixtures and specifications are given for: tank bottoms; bottom side blocks; top side blocks; and replacement blocks.

63. The Ceramic Society.

ANON. *Pottery Gaz.*, **44**, 489–96 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 841 (1919).—Some papers read before the English Ceramic Society. (1) Corrosive action of frits on refractories. Methods of slagging test described. (2) Substitution of apatite for bone ash in china. Compositions of 4 bodies are given and properties are described. (3) Heat conductivity of porous materials and heat insulation of kilns. Calculations as to rates of heat travel through porous body.

64. Notes on refractory materials.

ANON. *Pottery Gaz.*, **44**, 727–30 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 842 (1919).—Brick are protected by actual fusion of the surface or a protective coating of Carborundum plus 10% of fire clay. Resistance to slag action is much greater with the brick made under high pressure than those under low pressure. Brick made of bauxite clays are giving good results in the ports of gas-fired furnaces and the crowns of electric furnaces.

65. Standardization of tests for refractory materials.

ANON. *Trans. Ceram. Soc.* (Eng.), **18** [2], 516–17 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 334 (1920).—The 3 standard tests of slag penetration in fire clays and face brick are described. The methods are (1) refractory made into a hollow block filled with the slag and fired, (2) slag placed in a hole in the refractory, and (3) slag placed in a stoneware ring cemented to the brick.

66. The volatilization of iron from optical glass pots by chlorine at high temperatures.

J. C. HOSTETTER, H. S. ROBERTS, AND J. B. FERGUSON. *Jour. Amer. Ceram. Soc.*, **2**, 356 (1919).—Iron can be volatilized from glass pots under factory conditions. There is nothing difficult or impractical in carrying out the process. The iron which is absorbed by the glass from the pot may be removed at comparatively small expense by subjecting pots to the action of Cl or HCl vapors.

67. How slag temperature affects fire brick.

R. M. HOWE. *Brick and Clay Rec.*, **54**, 143 (1919); *Trans. Ceram. Soc.* (Eng.), **18**, 96A (1919).—A series of tests made on 3 types of fire brick, with 6 slags at various temperatures. Results are given in tabular form. The penetration was found to increase to a marked extent with higher temperature. Due to the increased penetration of the slag at the higher temperature, the life of the refractories is reduced, and the chemical action is also accelerated the higher the temperature.

68. Tests to determine uses for clays.

R. F. MACMICHAEL. *Brick and Clay Rec.*, **55**, 677–80 (1919).—Extensive tests are carried on to determine the uses for which clays are suited according to their properties in the plastic, dry, and fired state. A clay to be used as a refractory must have a high refractory index. This is indicated by the point at which the sample sags under its own weight in the kiln.

69. Notes on refractories.

J. W. MELLOR. *Engineering*, **107**, 647–48 (1919); *C. A.*, **13**, 1913 (1919).—A general discussion of the properties of clay refractories, especially fusing point. Rational

analysis is not considered of great value. See also *Pottery Gaz.*, **503**, 493–94 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 670 (1919).

70. Refractories.

J. W. MELLOR. *Jour. Soc. Chem. Ind.*, p. 180R, May 31, (1919).—A description of the changes taking place in clay, alumina, ferric and chromic oxides when heated. Endothermic and exothermic reactions. Changes in specific gravity. Test for adequate firing of refractory bricks. The raw materials needed for magnesite and silica bricks. Penetration and slagging of refractories by metallic oxides. This is best resisted by a composition of about 63% SiO_2 30% Al_2O_3. A porous open body best withstands abrupt temperature changes. The effect of porosity on toughness, permeability to gases and thermal conductivity is discussed.

71. Specifications for refractories for glassworks' use.

W. T. REES. *Trans. Ceram. Soc.* (Eng.), **18**, Pt. II, 420–30 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 332 (1920).—These provisional specifications have been adopted by the Council of the Society of Glass Technology and accepted by the Committee nominated by the Employers' National Council for the clay industries. *Tank Blocks:* At the request of the purchaser the following data shall be supplied for his personal information only, together with average samples true to bulk. (*a*) Analysis, showing content of silica, alumina, iron oxide, titanium oxide, lime, magnesia, potassium oxide, and sodium oxide. (*b*) Refractoriness measured by Seger cones. (*c*) Volume porosity. (*d*) Linear contraction or expansion after being heated to a temperature equivalent to cone 14. (*e*) Crushing strength. *Tests.*—1. *Refractoriness:* Cones cut from the blocks shall not be more fusible than cone 30. The test shall be carried out in an oxidizing atmosphere, the temperature of the furnace being increased regularly at the rate of 50°C per five minutes. 2. *Texture:* The block shall contain no patches of iron-stone or other segregated impurity. They shall be uniformly fired throughout, and if any blue, black, or brown core is present, it shall be of the minimum extent practicable having regard to the size of the block. The blocks shall be of regular texture and free from holes and flaws. The arrasses shall be as reasonably sharp as is consistent with the size of the grog used. All surfaces shall be sufficiently true and plain as to permit of the blocks being walled together without appreciable joint space on the exposed face. 3. *Porosity:* The volume porosity *i.e.* (the volume of pores $\times 100$) $\div$ volume of piece (including pores), shall not exceed: for flux line blocks 18%, for replacement flux line blocks 25%, for bottom side blocks 25%, for tank bottom blocks 30%. 4. *After-contraction or After-expansion:* Test pieces (about 3 inches in length and 1 and 2 inches in depth and breadth) taken from any portion of the block after being heated to, and maintained for two hours at a temperature equivalent to cone 14, shall not show when cold more than 2% linear contraction or expansion. When the test temperature has been reached the furnace shall be maintained constant throughout the test period. 5. *Crushing Strength:* The blocks shall be capable of withstanding a crushing strain of not less than 1600 pounds per square inch. The portion of block tested shall be a 4-inch cube and shall have the two ends which come in contact with the jaws of the machine ground or sawn flat and made truly parallel by facing with plaster of Paris in the usual way. 6. *Inspecting and Testing:* The purchaser or his representative shall have access to the works of the maker at any reasonable time, and shall be allowed to inspect the blocks before delivery. Duplicate test pieces representative of the bulk of the material ordered shall be selected prior to delivery. The cost of the blocks damaged for the purpose of obtaining test pieces shall be borne (*a*) by the purchaser when the material is proved satisfactory; (*b*) by the maker, if unsatisfactory. *Raw Clays and Grog.*—1. *Mixture:* Clay mixture for pots shall consist of at least three portions: (*a*) Bind clay, (*b*) base

clay, (*c*) grog. At the desire of the buyer the following data shall be supplied with samples true to bulk. 2. *Analysis:* The analysis shall show content of SiO_2, Al_2O_3, K_2O, Na_2O, TiO_2, CaO, MgO, Fe_2O_3, and the loss on ignition. 3. *Fusion Test:* This shall record: (*a*) Squatting temperature, measured by Seger cones, with equivalents in °C and °F. (*b*) Squatting temperature under load in °C and °F by standard test to be defined. 4. (*a*) The bind clay shall be a fat plastic aluminous weathered clay. (*b*) The base clay shall be a highly refractory clay. Lumps to be specially selected and hand-picked free from pyrites. (*c*) The grog shall be prepared from well-fired pieces of selected refractory clay. Fired blocks must show no sign of blue-stoning or black core. Nothing of the nature of ordinary fire brick shall be used for grog. 5. A sample of any portion when made up and fired to 1400°C shall not show decided speckling due to iron in a segregated form. 6. A fracture of each portion, when made up and fired to 1400°C, shall show a dense structure, especially the bind clay. A wide range of vitrification is necessary without signs of overfiring. 7. Clay and grog shall be loaded in clean bags securely tied. *Silica Bricks and Cement.*—At the desire of the purchaser the following data shall be supplied for his personal information only, with average samples true to bulk: (*a*) analysis, (*b*) refractoriness, (*c*) linear expansion after being heated to cone 12. 1. *Composition:* The bricks shall contain not less than 94% of silica, and not more than 2% of lime. 2. *Refactoriness:* Test pieces shall not be more fusible than cone 32 (about 1710°C). The test shall be carried out in an oxidizing atmosphere, the temperature of the furnace being increased at the rate of about 50°C per 5 minutes. 3. *After-expansion:* A test piece after being heated to a temperature equivalent to cone 12 for two hours shall not show on cooling more than 0.75% linear expansion. 4. *Texture:* The bricks shall be uniformly fired and shall have a regular texture with no holes or flaws. 5. *Variations from measurements:* All surfaces shall be reasonably true, and there shall not be greater variation than 2% from any specified dimension. Silica cement shall in all cases be finely ground and suitable for binding together the bricks for which it is supplied. It shall contain not less than 92% of silica and shall be capable of withstanding the same test for refractoriness as the brick. In the discussion emphasis was laid on the fact that these specifications are too stringent in some respects. See also *Jour. Soc. Glass Tech*, **6**, 181 (1922); *Ceram Abs.* **1**, 330 (1922).

72. Ultramicroscopic examination of some clays.

JEROME ALEXANDER. *Jour. Amer. Ceram. Soc.*, **3**, 621–25 (1920); *C. A.* **14**, 3138 (1920).—Eleven clays were subjected to ultramicroscopic examination to determine if any differences found were related to working properties. Full descriptions of properties are given.

73. The geology of the refractory materials of the North of England.

J. B. ATKINSON AND J. T. STOBBS. *Trans. Ceram. Soc.* (Eng.), **18** [2], 435–55 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 333 (1920).—The fire clays have no doubt accumulated under water from debris washed down by rivers. They are generally but not always associated with coal beds. A quarry at Pensher in Durham now furnishes blocks of the sand stone called "fire-stone" for the construction of tanks for holding molten glass. It is probable that the highly siliceous ganister rock in this district has long been used in its natural state as a refractory. Ganister rock generally mixed with fire clay and other materials, for the purpose of making "ganister bricks," would appear to have been first used near Sheffield, about 1858 or 1859.

74. Refractories for the zinc industry.

M. G. BABCOCK. *Jour. Amer. Ceram. Soc.*, **2**, 81–95 (1919); *C. A.*, **13**, 137 (1919).—Requirements for zinc retorts. (1) Refractoriness and heat conductivity. (2) Great

plasticity of bonding clay. (3) Strength both green and in use. (4) Good density at 1300–1400°C. (5) Thin walls with good heat conductivity. (6) Sound structure free from cracks during use. Raw materials, tests, compositions, protective coatings, and manufacture are discussed. The manufacture of condensers is also discussed.

75. The refractory products industry.

J. BIED. *Ceramique*, **22**, 33 (1919); *Ceram. Abs.*, **1**, 107 (1922).—See *Trans. Ceram. Soc.* (Eng.), **19**, 134 (1920).

76. Some criticisms by a firebrick manufacturer.

G. R. L. CHANCE. *Trans. Ceram. Soc.* (Eng.), **18**, 456–67 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 838 (1919); *ibid.*, **3**, 415 (1920).—Says that scientific investigations are of doubtful value.

77. Melting point of refractory materials.

L. I. DANA. *Bull. Amer. Inst. Min. Met. Eng.*, 1571–86 (1919); *ibid.*, 3153 (1919); *C. A.*, **13**, 3299 (1919); *ibid.*, **14**, 328 (1920).—Effects of size and shape of grain, time, and rate of heating, atmosphere pressure, nature of furnace atmosphere, etc., are discussed. Melting point should be observed under actual conditions of use. Ten per cent dextrin should be used as a binder if necessary in making cones. The rate of heating up to 1000° is not important. Above 1000° the rate should be from 5 to 10° per minute. Types of furnaces and pyrometers are discussed.

78. Refractory problems of the gas industry.

W. H. FULWEILER AND J. H. TAUSSIG. *Jour. Ind. Eng. Chem.*, **11**, 1153–57 (1919); *C. A.*, **14**, 337 (1920).—The uses of SiO_2 material and of fire clay in coal gas production. Also a discussion of various refractories and cement.

79. Refractory materials used in coke-oven construction.

W. C. HANCOCK. *Brit. Clayworker*, **28**, 155–58; *Jour. Amer. Ceram. Soc.*, **2**, 1018 (1919).—Requirements of the refractories are given and the silica and fireclay brick are compared as used in English and American practice. The qualities required are resistance to high prolonged heating under normal or increased pressure, resistance to abrasion, resistance to temperature change, impermeability of gases, and resistance to chemical attack. Due to the washing of coal in England fireclay brick are used instead of the silica brick, because the fireclay brick are not affected as much by the moisture.

80. Refractory materials.

J. W. MELLOR. *Coll. Guardian*, **117**, 479, 537, 719, 775 (1919); *Ceram. Abs.*, **3**, 268 (1924).—Synopsis of a series of lectures given before the Society of Chemical Industry. Dealing with the development and problem peculiar to the refractories materials problem.

81. Notes on the microstructure of zinc retorts.

ALEXANDER SCOTT. *Trans. Ceram. Soc.* (Eng.), **18** [2], 512–15 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 415 (1920).—The outer yellowish gray portion appears under the microscope to consist of sporadic quartz grains set in a matrix which is almost opaque. The matrix consists of a clear glass in which are innumerable microlites. Some of the latter appear to be sillimanite, but the majority are hexagonal zinc orthosilicate. As the blue portion is approached the latter increase in number while the amount of tridymite also becomes greater. A microsection of the flue material shows it to be partly crystalline and partly glassy. The original material of the matrix has been completely changed, the alumina having reacted with oxidized zinc to form spinel, while the silica appears partly as tridymite and partly as silicates of zinc and iron. Several syntheses of both

ortho- and meta-silicates of zinc are on record, but the evidence regarding the latter is somewhat unsatisfactory. It seems probable that under the conditions obtaining in zinc retorts, zinc oxide reacts with the free silica of the retort to form the orthosilicate and not the metasilicate. In each of the cases described above, the silica was in excess of that required to form the metasilicate, yet the final zinc salt was willemite. The results obtained above are in favor of Vogt's view that the orthosilicates of zinc and iron form two series of mixed crystals, one rich in zinc and crystallizing in the hexagonal system (willemite) and the other rich in iron and forming orthorhombic crystals (fayalite).

82. Refractory material as a field for research.

E. W. WASHBURN. *Jour. Amer. Ceram. Soc.*, **2**, 3–31 (1919).—This is a fully illustrated discussion of the need and method for a refractories research organization. It is set forth under the following topic heads: (1) definition of the term refractory material; (2) importance of the subject; (3) conservation of fuel; (4) annual production and consumption; (5) organization for the prosecution of research; (6) board of trustees; (7) scientific director and advisory committee; (8) statistics publication and indexing; (9) phase rule investigations; (10) physical constants; (11) standard methods for testing refractory products; (12) raw materials specifications; (13) manufacturing methods; (14) standard specifications for refractory products; (15) engineering; (16) geology and mining; (17) coördination and international coöperation; (18) financing the research organizations; (19) practicability of forming a refractories corporation.

83. Fire brick for use in oil gas generators.

D. J. YOUNG. *Progressive Age*, 11–1–12, p. 932.—Analyses and fire tests on 21 samples of fire brick taken from various parts of Europe and N. America.

84. Refractories for electric furnaces.

ANON. *Chem. Met. Eng.*, **23**, 769–70; *Jour. Amer. Ceram. Soc.*, **3**, 1003 (1920); *Mineral Foote Notes*, Sept.–Oct., 3–7 (1920); *C. A.*, **15**, 425 (1921).—Requirements for electric furnace refractories: (1) The melting point should be between 1700 and 1750°. (2) Should be very resistant to sudden temperature changes. (3) The refractories should not change in volume at electric furnace temperatures. (4) The bricks should be very resistant to corrosion since oxidizing and reducing slags are often present and those, together with the high temperature cause vigorous corrosion of the refractories. (5) Where a circulating metal bath is used as in the induction furnaces the refractories should be very resistant to abrasion. Different parts of the furnace must meet the following requirements: (*a*) The outer wall should be a good heat insulator and moderately refractory. (*b*) The hearth should have a high melting point, be inert toward slags, and be resistant to corrosion. (*c*) The roof should be resistant to slags and fumes, have a high melting point, and show small tendency to spall. Fire brick are used in the outer wall, magnesite in the inner walls, dead burned dolomite or magnesite rammed in the hearth and the roof is usually of silica brick. Zircite meets most of the above requirements.

85. Refractories for electric furnaces.

ANON. *Iron and Coal Trades Rev.*, **101**, 616 (1920); *Trans. Ceram. Soc.* (Eng.), **20**, 57A (1921).—The requirements for the electric furnace are outlined. The qualifications of fireclay, silica, dolomite, magnesite, chromite, bauxite, alundum, and carborundum bricks are discussed.

86. Tentative test for slagging action of refractory materials.

ANON. *Proc. A.S.T.M.*, **20**, 620–23 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 690 (1921); *C. A.*, **15**, 1200 (1921).—Analysis of the slag used is given, and the methods used for the test described.

87. Zinc retorts.

ANON. *Tonind. Ztg.*, **44,** 310(1920); *C. A.*, **14,** 1885(1920).—Quartz is not recommended because of high porosity and low resistance to sudden changes in temperature. Coke is sometimes added to make the retorts more resistant to sudden temperature changes. Retorts made of carborundum and zirconium are very resistant to sudden temperature changes. The use of a glaze which softens at 900° is recommended. Calcined clay or porcelain may be used as grog. The action of 15 flue-dusts, salts, etc. was studied. The analyses of the dust and brick are given. It was found that below 1300° the action of the material was mechanical rather than chemical. The penetration was greater on fireclay brick than with the silica brick. The greater the amount of fluxes present the greater the action of the dust. If the glaze was formed on the surface the rate of penetration was decreased. Facing the brick by fusing the surface failed because the surface skin cracked and peeled. The inversions of silica were accelerated by the action of the dusts.

88. Water-cooling of glass furnace refractories.

E. B. CHRISTMAS. *Jour. Soc. Glass Tech.*, **4,** 128–38(1920); *Jour. Amer. Ceram. Soc.*, **3,** 685(1920).—The Knox system is described.

89. Melting point methods at high temperatures. I.

LEO I. DANA AND PAUL D. FOOTE. *Chem. Met. Eng.*, **22,** 23–29(1920); *Jour. Amer. Ceram. Soc.*, **3,** 326(1920).—Use of thermoelectric pyrometers, pure materials. Of all crucible materials used for pure metals, Acheson graphite has the greatest utility. It is very pure, can be machined into any desired shape, and is not attacked by most of the common metals. Crucibles of magnesia, alumina, or mixtures of the two are suitable for iron and nickel. Porcelain crucibles may be used for many of the metals, but there is always danger of these cracking when the metal melts or freezes. Up to 500°C protection tubes and insulating tubes for the couple made of Pyrex glass are useful. From 500 to 1100°C, lower grade porcelain glazed on the outside only or fused quartz is satisfactory. Above 1100°C, tubes having a composition approximating that of sillimanite, Al_2O_3 SiO_2, are recommended. The more common metals which can be used for the standardization of thermocouples by the crucible method, with their melting point in °C are: tin 231.9, bismuth 271, cadmium 320.9, lead 327.4, zinc 419.4, antimony 630.0, aluminum 658.7, silver 960.5, gold 1062.0, copper 1083.0, nickel 1452. Furnaces wound with "Chromel A" wire are used up to 1000°C. In alloys and mixtures if the ordinary temperature-time curve does not give evidence of a melting range or of a transformation point, the more sensitive inverse rate method and differential method may be employed. The former consists in determining the time required for the specimen to fall a definite temperature interval, and in plotting this time against the temperature. The differential method is still more sensitive and consists in measuring the temperature differences between the material in which the transformation takes place and a neutral body having no transformation points in the same temperature interval, such as platinum or nickel, and plotting this difference against the temperature of the material.

90. Refractory materials.

P. S. DEVEREUX. *Chem. Trade Jour.*, **66,** 567–68(1920); *C. A.*, **14,** 2246(1920).—Adding SiO_2 will lower and not raise the melting point of a refractory. Chromite cannot be used above 1500° for it will disintegrate. Brick made from fused alumina show very low shrinkage, and very high resistance to abrasion and slags. If Al_2O_3 in any quantity up to 7% is added to pure MgO the melting point is lowered from 2800 to 2030°. Mixing 72% Al_2O_3 and 28% MgO will form a definite chemical composition usually in small interlaced crystals

91. The behavior of refractory brick under load at high temperatures.

K. ENDELL. *Stahl u. Eisen*, No. 12 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 419 (1921).—An eye-beam 4 m. long was employed as a lever arm to apply a load of 1 kg. per sq. cm. to a refractory cylinder 5 cm. diameter and 5 cm. high, the pressure being applied by a hard carbon rod. A pointer moving over a scale indicated expansion, contraction, and deformation. A carbon resistance furnace with a free working space 12 cm. in diameter was employed. Temperatures were determined to $\pm 10°$ with a Holborn-Kurlbaum optical pyrometer sighted through an opening in the side of the furnace.

BEHAVIOR OF VARIOUS REFRACTORIES UNDER LOAD OF 1 KG. PER SQ. CM. AT HIGH TEMPERATURES

Material	Melting point °C	Max. furnace temp. °C	Deformation temp. °C	Deformation m.	Heating time: Total	Heating time: Above 900°	Remarks
Fire clay	1730	1500	1300	30	4h 30′	3h	The cylinder exhibits lateral expansion due to homogeneous deformation.
Magnesite	>2000	1650	1500	10	4h 45′	3h 30′	Circular fracture with little deformation.
Silica brick	1750	1680	1650	broken	4h 10′	2h 50′	The compression takes place in jumps, the broken pieces showing little deformation.
Carbon brick	2000	1720	No deformation		4h 55′	3h 25′	No deformation but 4% shrinkage due to loss of carbon and bond from combustion and volatilization.

92. Air cracks in refractories.

F. FISCHER. *Tonind. Ztg.*, **44**, 1270 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 686 (1921).—F. differentiates between air cracks and shrinkage cracks. Air cracks are caused by rapid heating and cooling, while shrinkage cracks develop during firing. Air cracks are very fine, while shrinkage cracks are wide. When a piece of ware is broken it usually cracks along the air cracks.

93. The development of the refractories industry in general and especially during the last war.

H. GEYER. *Ber. deut. keram. Gesell.*, **1** [2], 33–45 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 240 (1921).—Production of ceramic material has doubled since 1900. The present output is about 1,000,000 tons, which is only ⅔ normal. There are one hundred factories and they employ 35,000 workers. 250,000–300,000 tons of coal are used annually. The business statement of the United Chamotte Factory of Marktredwitz, whose annual production is about 25,000,000 kgs. follows: raw material 15.1%; coal 9.7%; expense of operating machinery 4.7%; wages 25.4%; operating expenses, 8.6%; sales expenses 15.8%, of which 5.4% is for salaries; warehouse costs 7.9%; gross profit 12.8%, total 100%.

94. Spalling losses and comparative cold and hot abrasion tests.

M. L. HARTMANN AND O. A. HOUGEN. *Trans. Amer. Electrochem. Soc.*, **36,** preprint; *Jour. Amer. Ceram. Soc.*, **3,** 582 (1920); *C. A.*, **14,** 2246 (1920).—Spalling losses were determined on various fire brick after heating to 1350° and cooling with an air blast 10 times. Hot abrasion tests were also made by heating brick to 1350° and holding them against a Carborundum grinding wheel at a constant pressure. The depth of abrasion was then used as a means of comparison. Bonded Carborundum was the best tried (Carbofrax C). A table of results is given.

95. Physical characteristics of refractories. I. Spalling losses. II. Cold and hot abrasion tests.

M. L. HARTMANN AND O. A. HOUGEN. *Trans. Amer. Electrochem. Soc.*, **36,** preprint (1920); cf. *C. A.*, **14,** 2246; *Jour. Amer. Ceram. Soc.*, **4,** 239 (1921).—I. Comparative tests were made on 12 different kinds of refractory bricks purchased in the open market, exposed to rapid cooling in an air blast from a temperature of 1350°. Three of these kinds were completely disintegrated at the 7th, 4th, and 3rd treatment. The others were treated 10 times. The three bonded Carborundum varieties showed the least spalling (under 8%). Chrome brick was all gone after the 7th test, silica after the 4th, and magnesia after the 3rd. II. A Carborundum cutting wheel was used for the hot and cold abrasion tests and the abrasion in a given time, under equal pressures, noted. Again the bonded Carborundum have the best results. In discussion, it was brought out that this test was probably very much affected by differences in heat condition.

96. Physical characteristics of specialized refractories. IV.

M. L. HARTMANN AND W. A. KOEHLER. *Trans. Amer. Electrochem. Soc.*, **40,** preprint (1921); *Ceram. Abs.*, **1,** 67 (1922).—The cross-breaking strength of each of 10 refractories was determined at 20° and 1350°. Within this temperature range chrome brick showed the most decided drop in modulus of rupture followed by bauxite, MgO, fire clay, and SiO_2. Chrome bricks at 1350° have a breaking strength of $\frac{1}{63}$ of their cold-breaking strength. Two bonded SiC refractories showed an increase, indicating that the decrease occurs at a higher temperature than 1350°.

97. Laboratory melting furnace with electrical heating.

HANS HECHT. *Chem. Ztg.*, **44,** 956 (1920); *Jour. Amer. Ceram. Soc.*, **4,** 416 (1921).—A vertical alundum tube furnace with a resistor of powdered carbon and a vertically adjustable table for supporting the 600-cc. crucible. The crucible may be tapped, in place, if desired, the charge flowing out through the hollow supporting column of the table. 150 A. at a 110 V. gives temperatures up to 1700°C.

98. Refractory lining.

W. G. LAIRD. U. S. 1,328,380, Jan. 20, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 416 (1920).—Fire brick made of fire clay and silica do not withstand the fluxing action of ash, alkalis, etc. Refractories such as carborundum, fused alumina, magnesia, etc. are resistant to fluxing action. Attempts to face the brick with a coating failed due to unequal expansions. Success has been attained by the use of slabs, held in place by locking blocks placed between the ends of the fire brick.

99. Furnace for testing fire brick under load at high temperature.

C. H. LOVEJOY. *Chem. Met. Eng.*, **22,** 109; *Jour. Amer. Ceram. Soc.*, **3,** 162 (1920).—Description of a load test furnace for fire brick in use at the Pittsburgh Testing Laboratory, with plans for building furnace. The main difference between this furnace and type outlined by A.S.T.M. lies in the manner of applying load and the means of determining load during failure of brick under test. Pressure is applied by means of a spring,

which carries brick to ultimate failure, determines variation in load sustained by brick at higher temperatures and gives rate of failure. A pressure of 50 lbs. per sq. in. is used, which is double that recommended by the A.S.T.M. The pressure is obtained through blocking, passing through bottom of furnace. The flame is led out through a chamber in back of furnace to prevent burning off of outlet pipe. Rate of heating is 500°C in first hour and up to 1350°C in five hours with this temperature maintained for one hour. Poor brick start to fail at as low as 950°C or 1000°C. Such brick show complete failure below 1200°C, the spring having returned to its original length with the load reduced to zero. Load remains constant in test and different rates of heating for different grades of brick are suggested. Fair brick will start to fail at about 1100°C and the spring will have about 25 pounds pressure per square inch left on them at 1350°C. First class brick will generally show no signs of failure before 1200°C, and many will stand 1300°C before starting to fail. Only two bricks were found which would show no sign of failure at 1350°C. All brick fail below 1500°C.

100. Refractories for coke ovens.

W. J. Rees. *Coll. Guardian*, **119,** 378 (1920); *Ceram. Abs.*, **3,** 266 (1924).—Properties desirable for coke-oven refractories: (1) Temperature likely to exceed 1350°C. (2) Load not high enough to lower the refractoriness of the brick. (3) The brick and cement used must be gas tight. (4) Resistant to the abrasion of the coal and coke. (5) Resistant to the corrosion caused by the salts. Most important factors to be dealt with. See also *Gas Jour.*, **149,** 309–12 (1920); *Gas World*, **72,** 913 (Coke Section) (1920).

101. War experience with refractory bricks in the German navy.

Schultz. *Tonind. Ztg.*, **44,** 1047 (1920); *Ceram. Abs.*, **5,** 107 (1922).—Specifications include the following softening points, cone 34 for grade 1, cone 31 for grade 2, and cone 26 for grade 3.

102. Brick for malleable furnaces.

H. G. Schurecht. *Foundry*, **50,** 707–10 (1920); *C. A.*, **16,** 3739 (1922).—In malleable iron furnace bungs it has been found that fireclay brick passing the usual load and softening tests have often failed. Tentative conclusions: (1) Firing to cone 8 gives greater resistance to spalling than firing to cone 10. (2) High load tests and fusion tests are not of primary importance. (3) Spalling test seems the best guide. (4) Bricks showing 15–28% porosity and 1.0–2.3 density were best. SiC brick were good but their heat conductivity was too high. (5) The ratio of RO_2 to $RO+R_2O_3$ of the best brick was between 1.5 and 2.5. The order of withstanding the spalling test was: (1) Carborundum, (2) fireclay brick, (3) silica brick, (4) magnesite brick. The properties of fireclay brick are governed by: (1) selection of clays, (2) size of grain, (3) proportion of non-plastic and plastic ingredients, (4) fineness of grain of the bonding material, (5) manner of molding, and (6) temperature of firing. An excellent article on determining the quality of fire brick.

103. Elutriation test on American kaolins.

H. G. Schurecht. *Jour. Amer. Ceram. Soc.*, **3,** 355–78 (1920).—A large amount of data is given showing elutriation tests on many samples both American and foreign. Necessary precautions in making the tests include: (1) use of distilled H_2O in place of tap H_2O; (2) a thorough stirring every day (usually three days for a test) of the residue in each can; (3) deflocculation of the clay sample and feeding drop by drop with velocity of H_2O flow reduced about $\frac{1}{3}$ during this period. Results show that Georgia, S. Carolina, and Pennsylvania kaolins contain a high per cent of clay-like substance below 0.010

mm. comparing favorably with English china clay. The N. Carolina kaolins showed a comparatively low per cent of fine material. English ball clay contains an extremely high per cent of fines, 98.55 % being carried away by H_2O flow of 0.0197 mm. per second. Only 40.75 % of English kaolin was carried away by this velocity. The great plasticity and bonding power are due largely to their finer grains.

104. Coagulation of clay suspensions and silicic acid.

O. M. SMITH. *Jour. Amer. Chem. Soc.*, **42**, 460–72 (1920).—The coagulation of clay suspensions is aided by the trivalent and hindered, at certain concentrations, by the univalent cations in the presence of HCO_3, CO_3, SO_4, and OH ions. Silicic acid retards the coagulation of clay suspensions and is best precipitated at a *p*H of 8:25. Solid $Al(OH)_3$ is stable between a *p*H of 4 and 11.

105. Thermal expansion of insulating materials.

W. H. SOUDER AND PETER HIDNERT. Bur. Standards, *Sci. Paper*, **352** (1919); *Jour. Amer. Ceram. Soc.*, **3**, 576 (1920).—In the furnaces used for tests, the specimen was supported horizontally and a 2 mm. platinum wire hung over each end. Each wire, hanging through a hollow tube below the end of the specimen and extending downward through and below the furnace, had at its lower end a vane (or weight) immersed in oil in order to dampen the vibrations. Heating was effected by electric resistance coils (outside, inside, and end coils). The length changes were determined with a comparator consisting of two microscopes rigidly clamped on an invar bar at a distance from each other equal to the length of the specimen (30 cm.). The microscopes were first sighted on a standard-length bar kept at constant temperature, and then on the vertically suspended wires which were in contact with the ends of the specimen. Data on the thermal expansion of 40 samples of various kinds of porcelain are presented. The expansion curves of porcelains may be divided into three classes: straight-line, concave, and convex curves. The expansion curves of most materials are concave. No marked set or permanent change in dimension due to the heat treatment was observed. Porcelains having low coefficients exhibited marked resistance to sudden temperature changes. Most phenol condensation products (bakelite, condensite, formica, etc.) shrink and lose weight when subjected to temperatures above 60°C. Marble and limestone showed a permanent growth when subjected to heat treatment. On cooling below room temperature, it was found that marble has a negative coefficient of expansion.

106. Possibilities for research and development in the field of refractories.

H. F. STALEY. *Chem. Met. Eng.*, **23**, 1167–71 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 314 (1921).—Some of the reasons for the research in refractory materials are given. Staley considers a phase-rule investigation of fire clay, permanence of volume, glass-house refractories, zinc retorts, saggers, sillimanite, silica, magnesite, Carborundum, alumina, and zirconium refractory, carbides and nitrides and insulating materials.

107. The measurement of physical properties at high temperatures.

A. GEORGE TARRANT. *Trans. Faraday Soc.*, **15** [3], 83–97 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 166 (1921).—It was found that *breaks in the carbon spiral of an electric resistance furnace* could be easily and completely repaired by heating the break by passing current and applying a mixture of graphite and synthetic resin, which flowed into the hot crack and subsequently became carbonized.

108. The corrosion of coke-oven walls.

H. V. THOMPSON. *Pottery Gaz.*, **45**, 770 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 690 (1920); *C. A.*, **14**, 2540 (1920).—Highly aluminous clays developing a large proportion of sillimanite are much more resistant to salt attack than the ordinary fireclay brick.

There seem to be possibilities in the use of aluminous fire brick in the construction of coke ovens. The method of making SiO_2 brick greatly influences their serviceability in coke ovens.

109. Note on the tensile strength of refractory materials.

MORRIS W. TRAVERS. *Jour. Soc. Glass Tech.*, **4**, 138–39 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 923 (1920).—In many places in furnace construction and especially in pot walls, tension and not compression is the important property. Changes which increase resistance to load may have a very different effect on tensile strength. The theory that an ideal refractory should consist of a very high percentage of infusible material, carefully graded and bonded with a very small quantity of vitreous bond may be justified from the standpoint of resistance to load, but it does not follow that tensile stresses will be equally well withstood. The ideal refractory consists of a system of interlocking crystals formed *in situ*, in a glassy matrix. If the matrix is such as to form a sillimanite layer in contact with alkaline fluxes, then corrosion by glass is largely avoided, for such a layer greatly delays the mixing of the liquid phases on either side of it.

110. A possible explanation of failure under load at high temperatures as displayed by fireclay refractories.

A. S. WATTS. *Jour. Amer. Ceram. Soc.*, **3**, 448–59 (1920); *C. A.*, **14**, 2691 (1920).—Failure may be due to the period of weakness occurring at the time of decomposition of the clay, especially of high Al_2O_3 clays, and recombination of the Al_2O_3 and the SiO_2 as sillimanite. Sillimanite may be the product of molecular rearrangement without fusion and this explains low temperature failures. Hard firing helps develop sillimanite and increases resistance in load test which is against this theory. In most cases failure under load must be due to fluxing of the bond clay.

111. Refractory brick for blast furnaces.

ANON. *Brit. Clayworker*, **30**, 3 (1921); *Ceram. Abs.*, **1**, 66 (1922); *C. A.*, **16**, 808 (1922).—The brick should meet the following requirements: (1) resistance to abrasion, (2) resistance to chemical action of slags, metals, and gases, (3) resistance to high heat, and (4) resistance to sudden temperature changes. The fire boxes and the bottom of the furnace should be lined with brick having the composition 63 % Al_2O_3 and 37 % SiO_2 and should be fired at 1300°.

112. Tentative method of test for resistance of fireclay brick to spalling.

ANON. *Proc. A.S.T.M.*, **21**, 577–78 (1921); *Ceram. Abs.*, **1**, 66 (1922).—The object of the test is to determine the resistance to spalling action by subjecting the brick to repeated rapid temperature changes. Instruction for the preparation of samples, and the detailed procedure is then given.

113. Abrasive and refractory article and method of producing same.

ALBERT H. ANDERSON. U. S. 1,364,849, Jan. 4, 1921; *Jour. Amer. Ceram. Soc.*, **4**, 24 (1921).—A combination of matter for forming ceramic articles comprising refractory or abrasive crystalline grains, a plastic clay, water, and an oily lubricating agent.

114. Effect of impurities in fire clay.

C. E. BALES. *Brick and Clay Rec.*, **59**, 723–25 (1921); *Jour. Inst. Metals*, **30**, 699; *C. A.*, **18**, 2588 (1924).—Excessive SiO_2 reduces refractoriness and makes the product friable. Iron compounds act as fluxes, are coloring agents, and increase the shrinkage. Ferrous iron is extremely harmful. CaO acts as a flux, makes the brick friable, if in large pieces, and neutralizes the color produced by the iron. Na_2O and MnO are active fluxes. TiO_2 is a flux and acts as a coloring agent. Mn is a coloring agent. Car-

bonaceous matter reduces ferric to ferrous. Excessive water causes cracking and brings soluble salts to surface.

115. Expansion of some refractory materials at high temperatures.

B. BOGITCH. *Compt. rend.*, **173**, 1358–60 (1921); *Ceram. Abs.*, **1**, 163 (1922).—Expansion curves for bricks of fused bauxite, clay, silica, chromite, and magnesia over the temperature range 0° to 1600°C are given. The smallest expansion is shown by the fused bauxite, which is suitable for the construction of furnaces subject to sudden changes in temperature. Silica bricks showed the most irregular expansion. They expanded rapidly up to 600°C and then only very slowly, and above 1000°C showed a slight contraction. The curve shows two break points in vacuum.

116. Behavior of clay pyroscopes and fireclay bricks in coal gas.

L. BRADSHAW AND W. EMERY. *Gas World*, **74**, 503–504 (1921); *Ceram. Abs.*, **1**, 9 (1922).—Seger cones when heated in coal gas to temperatures well above their ordinary softening points remained erect. On examination, they were found to consist merely of a hollow shell with a quantity of slag discharged at the base, or of a semi-vitrified mass covered with an infusible skin. The outer shell was extremely refractory. It appeared to be due to the formation of a thick film of hard carbon in intimate contact with the surface of the cone. This effect was found to be due to the decomposition of CH_4 which forms a peculiarly hard and lustrous type of carbon. Fireclay brick heated under the same conditions assumed a similar surface deposition. The idea of a protective coating of hard carbon artificially produced on fireclay surfaces might possibly be utilized in gasworks practice, as the refractoriness of the shell is very much higher than that of the untreated material.

117. Behavior of refractory brick under load at high temperatures.

K. ENDELL. *Trans. Ger. Ceram. Soc.*, **2**, 73 (1921); *Stahl u. Eisen*, **41**, 6–9 (1921); *Ceram. Abs.*, **1**, 208 (1922).—Cylinders of refractory materials 2 in. diameter and 2 in. high are heated to 1700°C in an electric resistance furnace and pressure applied by means of suitable lever arrangement. Results of 4 tests are given. (1) Clay brick: initial softening about 1300°C. If plastic clay is used the temperature should be about 1150°. (2) Magnesite brick: initial softening about 1500°. (3) Silica brick: initial softening about 1650°. (4) Carbon brick; no signs of softening up to 1700°C.

118. Corrosion of coke-oven walls.

A. E. FINDLAY. *Jour. Soc. Chem. Ind.*, **40**, 7–8 (1921); *C. A.*, **15**, 1206 (1921).—F. reports on the investigation: (1) As the amount of salt increases the durability of the walls decreases. (2) Life further diminished if both salt and iron contents are high. (3) High iron and moisture with small amounts of salt have little effect on the walls. (4) Higher temperatures in vertical flues tend to shorten life of the walls.

119. Report on refractory materials.

W. H. FULWEILER. *Gas Age-Rec.*, **48**, 653–54 (1921); *Ceram. Abs.*, **1**, 140 (1922).—Progress report of the Committee on Refractories of the American Gas Association. For water gas machine linings chromite, mica schist, and SiC have thus far proved unsatisfactory. Zirkite and sillimanite are under observation.

120. The transverse strength of fireclay tiles at furnace temperatures.

R. F. GELLER. *Jour. Amer. Ceram. Soc.*, **4**, 608 (1921).—Commercial fireclay tiles were tested at furnace temperatures for transverse strength. This was supplemented by tests of tiles of known composition made in the laboratory. Moduli of rupture

obtained varied from 245.5 pounds per square inch at 1275°C, to 28.9 pounds per square inch at 1350°C but the data collected do not warrant definite conclusions.

121. Refractories for oil-fired furnaces and boilers.

W. H. GRANT. *Jour. Amer. Ceram. Soc.*, **4**, 390–92 (1921); *C. A.*, **15**, 4043 (1921).—Failure results from (1) spalling and falling of the side wall bricks, (2) disintegration of bricks in direct path of the flame, (3) glazing and resultant penetration and weakening by the glaze, (4) erosion by the flame. Discussion on paper, *Bull. Amer. Ceram. Soc.*, **4**, 390 (1921).

122. A study of spalling.

R. M. HOWE AND R. F. FERGUSON. *Jour. Amer. Ceram. Soc.*, **4**, 32–46 (1921); *C. A.*, **15**, 2344 (1921).—Air and H_2O quenching compared and checked against results in service. The method of testing and some of the causes of failure are described.

123. Refractories in the steel plant.

A. A. HULL. *Iron Age*, **25**, 1377–78 (1921); *Ceram. Abs.*, **1**, 107 (1922).—A plea for adequate specifications and coöperation between producer and consumer.

124. Investigation of refractory materials; the after-contraction test.

D. A. JONES. *Gas World*, **75**, 422 (1921); *Gas Jour.*, **156**, 598 (1921); *Ceram. Abs.*, **1** [5], 141 (1922).—Preliminary report from the Institute of Gas Engineers, Refractory Materials Committee. Whole bricks, not small pieces, are used. The bricks are heated in a surface combustion furnace, the heat being raised for 4 hours and maintained at the maximum temperature (cone 14 for fire brick, cone 12 for silica brick) for two hours. Considerable diversity is shown in the readings on account of the unevenness of the surfaces and the dislocation of the surfaces after firing. Marks should be made on the brick, and the variation between these measured by reading microscopes.

125. Report of Committee C-8 on refractories.

R. C. PURDY AND W. H. FULWEILER. *Proc. A.S.T.M.*, **21**, 315–16 (1921); *Ceram. Abs.*, **1**, 66 (1922).—The present tentative method for ultimate chemical analysis of chrome ores and chrome brick has been adopted as standard by A. S. T. M. A proposed method of test for resistance of fireclay brick to spalling action has been adopted as tentative. Investigation of conditions under which refractory materials are used in the steel industry is practically completed. A study on microstructure is also under way.

126. A method for the determination of the hardness of refractory materials at high temperatures.

E. RENGADE AND E. DESVIGNES. *Compt. rend.*, **173**, 134–37 (1921); *Ceram. Abs.*, **1**, 39 (1922); *C. A.*, **15**, 3731 (1921).—Ludwick's modification of the Brinell test for hardness was applied to 18 clay bricks and one bauxite maintained at temperatures varying from 1050 to 1490° in a graphite resistance furnace. Analysis of the compositions show that the Al_2O_3 content has small effect, but that the presence of alkalis causes considerable diminution in the hardness values.

127. Recent developments in refractories.

W. F. ROCHOW. *N. J. Ceramist*, **1**, 181 (1921); *Ceram. Abs.*, **2**, 15 (1923); *C. A.*, **17**, 192 (1923).—The sources and properties of the raw materials and the volume changes, a spalling test, melting point, load carrying capacity, thermal conductivity, manufacture, and uses of silica brick are discussed. The raw materials, manufacture, compositions, and uses of fireclay brick are discussed. The raw materials, compositions, and uses of carbon or graphite refractories are given. The sources of dolomite are given; its only notable use is for steel furnace bottoms. Patented magnesia block have the magnesia

rammed into an iron case. This case increased the life of the block many times. Raw materials, properties, and uses of bauxite refractory materials are mentioned.

128. Refractories and their application to gas works and coke ovens.

P. G. STRASSMANN. *Gas u. Wasserfach.*, **64**, 777–81; 798–801; 811–18(1921); *Ceram. Abs.*, **1**, 163(1922).—The clay and quartzite resources of Germany, their properties, and manufacture into refractories are discussed.

129. The determination of the thermal conductivity, specific heat, density, and thermal expansion of different rocks and refractory materials.

Y. TADOKORO. *Science Repts.*, Tohoku Imp. Univ., **10**, 339–410(1921); *Ceram. Abs.*, **1**, 208(1922).—This extensive report covering 109 specimens of Japanese and Asian rocks and refractory materials contains 18 tables and 45 figures. For determining the thermal conductivity the test specimen is periodically heated and cooled and the penetration of the temperature wave into the interior measured, the diffusibility being calculated by means of Fourier's series. A purely sinusoidal heat source was devised using a variable resistance in a plectrum form. This and the methods for the other properties are described in great detail. The conductivity increases with content of magnesia, but decreases with that of silica, lime, and alumina. Densities are calculated from the coefficients of expansion. Silica bricks are most suitable for installation of a reservoir of heat, the temperature of which is required to rise as quickly as possible when hot gas comes into it, and to cool quickly when cold air comes in. Chamotte bricks are most suitable for thermal insulation.

130. Tentative method of test for slagging action of refractory materials.

ANON. *A.S.T.M. Tent. Stand.*, 293, 1922; *Ceram. Abs.*, **2**, 99(1923).—A fireclay ring is cemented with refractory cement on the brick tested, and a synthetic slag placed within the ring. The prepared brick is fired to 1350°C for 2 hours. When cold the brick is broken through the center of the ring and the penetration and attack by the slag noted and measured with a planimeter.

131. Tentative method of test for resistance of fireclay brick to spalling action.

ANON. *A.S.T.M. Tent. Stand.*, 297, **1922**; *Ceram. Abs.*, **2**, 98(1923).—Bricks are given a preliminary heating for five hours at 1400°C. One end is exposed in door of furnace to 1350°C for one hour, then removed and put in cold running water for 3 minutes. Alternate heatings and coolings are made until the end of brick spalls off.

132. Bricks for crucible furnaces.

ANON. *Brit. Clayworker*, **31**, 224(1922); *Trans. Ceram. Soc.* (Eng.), **22**, 25A(1923). —Chief causes of failure are: (*a*) Corrosive action of ash in the fuel; (*b*) abrasion of descending fuel; (*c*) strains set up by sudden temperature changes; (*d*) partial fusion of the refractory materials. The bricks best suited to meet these requirements in the different parts of the furnace are indicated.

133. Action of refractories under load conditions at high temperatures.

ANON. *Bull. Amer. Ceram. Soc.*, **1**, 121–22(1922).—An editorial giving credit to Lemon Parker as originator of the load test.

134. Fire brick.

ANON. *Industrial Canada*, **23**, 94(1922); *Ceram. Abs.*, **1**, 315(1922).—A hitherto unknown industry in Canada is to be established by the Canadian By-products Co., Ltd., at Hamilton. They propose manufacturing fire brick, fireproof building brick, and tile, under 4 basic patents. The plant will have a capacity of 20,000 fire brick and miscellaneous refractories and will be able to supply the demand hitherto supplied by importation from U. S. and Scotland.

135. Molds for magnesite, chrome, and silica brick.

ERLING E. AYARS. *Jour. Amer. Ceram. Soc.*, **5**, 67–84 (1922).—*Shrinkage.* Determination of allowance for shrinkage in mold manufacture is of prime importance. Design comes next. *Types of Molds.* Slip molds including the open slip and vent bottom types, steel slip liner molds, and the wooden knock-down screw mold. *Materials Used.* Soft steel, cold rolled steel, galvanized iron, and hard woods. *Molding Tools.* The slicker, short scoop, smacker, putty knife, rammer, and hammer. *Manufacture of Molds.* Relation to the manufacture of all kinds of brick made from these special refractory materials. The treatment of each type of mold includes materials and method of manufacture, the materials and kinds of brick, the manufacture of which it is best suited, together with the manipulation best suited to turning out a uniformly good product. Correction of mold faults and suggestions for overcoming difficulties encountered in molding brick find their place wherever the discussion of the various molds and operations suggests any of the common troubles of the molder.

136. The influence of oxidizing and reducing atmospheres on refractory materials.

L. BRADSHAW AND W. EMERY. *Trans. Ceram. Soc.* (Eng.), **21**, 107–52 (1922); *Ceram. Abs.*, **1**, 315 (1922); *C. A.*, **16**, 4317 (1922).—Seger cones heated in a current of coal gas stood erect at temperatures far above their normal softening points. These cones were found to consist of merely a hollow shell with a quantity of slag discharged at the base, or of a semi-vitrified mass covered with an infusible skin. The outer shell is extremely refractory. It appears to be due to the formation of a thin film of hard C in intimate contact with the surface of the cone.

137. Report of the Refractory Materials Research Committee.

A. E. BROADBERRY. *Gas World*, **76**, 553–59; *Gas Jour.*, **158**, 840–52 (1922); *Ceram. Abs.*, **1**, 278 (1922).—Reference is made to the need of improvement of after-expansion or after-contraction tests and changes are suggested. Results of experiments on the relationship between porosity and thermal conductivity indicate that at high temperatures some of the pore spaces lose their insulatory properties and even at 1100° have the capacity for transmitting heat at rates comparable with solid matter.

138. Note on refractories engineering.

W. E. DORNBACH. *Bull. Amer. Ceram. Soc.*, **1**, 43–45 (1922).—A brief outline of training necessary to fit one for work as a refractories engineer. Nature of the work, its present day importance, and one verbal illustration of the work of such an engineer are cited.

139. Electrical resistivity at high temperatures.

M. L. HARTMANN, A. B. SULLIVAN, AND D. E. ALLEN. *Brick Pottery Trades Jour.*, **30**, 16 (1922); *Ceram. Abs.*, **2**, 18 (1923).—Fireclay bricks of A quality, bauxite, silica brick with CaO bond gave very regular resistivity curves. SiC gave similar curves, the resistivity being constant when the bricks were maintained at 1500°. Carbofrax B shows a rapid decrease in resistivity with increased time of heating. Recrystallized SiC (Refrax) has quite regular curves. The resistivity curves of MgO brick for heating and cooling are quite different in shape. The difference between heating and cooling of zirconia is very marked. Coarse-grained chrome brick possess low resistivities at all temperatures.

140. Disintegration of blast furnace linings.

R. M. HOWE. *Blast Fur. and Steel Plant*, **10**, 161–63 (1922); *Ceram. Abs.*, **1**, 181 (1922); *Trans. Ceram. Soc.* (Eng.), **21**, 73A (1922).—Analyses are given of deteriorated linings in which no zinc was found, although the action of the linings was similar to those

before (in preceding articles of the original publication). There was an increase in potash, carbon, and other substances. A review of the work on this subject since 1876. Cf. *Trans. Amer. Inst. Min. Eng.*, **32**, 437 (1903); *Stahl u. Eisen*, **18**, 168 (1917); *Stahl u. Eisen*, **23**, 823 (1903); *Bull. Amer. Inst. Min. Eng.*, No. 5 (1920).

141. Effect of weather upon the strength of refractory brick.

R. M. Howe, S. M. Phelps, and R. F. Ferguson. *Jour. Amer. Ceram. Soc.*, **5**, 107–11 (1922).—Magnesia and silica brick should be protected from the action of the weather. Open textured fireclay brick (usually having end cold crushing strengths of less than 1500 pounds per square inch) should be afforded protection from the action of the weather. Finely ground, dense, hard-fired fire brick, especially those of medium or low refractoriness, may be exposed to the action of weather with a reasonable amount of safety. These are usually made from one clay which is shaped on a dry press or auger machine and have an end cold crushing strength approximating 5000 pounds per square inch.

142. Research is tool which will improve refractories.

W. A. Hull. *Brick and Clay Rec.*, **60**, 544–45 (1922); *Ceram. Abs.*, **1**, 251 (1922).—H. states that user and consumer should know refractories; that tridymite improves silica brick; that furnace designs should be given more attention; that chrome Fe ore is good refractory; and that special refractory oxides and silicates should be investigated.

143. A study of refractories.

W. A. Hull. *Ceramist*, **2**, 205 (1922); *Ceram. Abs.*, **2**, 52 (1923).—General discussion of the properties and uses of refractories and a résumé of literature and of work done at the Bureau of Standards on refractories. Short discussions of the Technologic Papers of the Bureau of Standards on the fusion point, testing (especially load carrying ability) properties of European fire clays, size of grog, bond clays, porosity, specific gravity, heat treatment by-product coke oven service, specifications, tests, standards, and refractories for the steel industry.

144. Thermal conductivity of refractories.

W. A. Hull. *Chem. Met. Eng.*, **27**, 538 (1922); *Ceram. Abs.*, **2**, 15 (1923).—A review of the literature on thermal conductivity of refractories. Formulas are given. Enough variations enter in use that an approximation of the coefficient of thermal conductivity is sufficient in engineering calculations. A table of coefficients is given.

145. Refractories.

D. Louis. Can. 225,725, Nov. 7, 1922; *Ceram. Abs.*, **2**, 53 (1923).—A porous refractory material contains 30 parts of pure rich refractory earth containing 70–80% sand, 30 parts MgO; 25 parts light earth containing 80% sand and 5 parts sawdust.

146. Refractories.

G. McGill. *Coll. Guardian*, **123**, 91 (1922); *Ceram. Abs.*, **3**, 197 (1924).—Necessary factors in the conduct of firebrick works: (1) continuous sampling and analysis of mixture in use, both chemical and physical, (2) the use of heat recorders in kilns, (3) definite limiting standards for size and shape, (4) guaranteed working to specifications.

147. Blast furnace lining failures caused by zinc.

P. O. Menke. *Iron Trade Rev.*, **70**, 1409–10 (1922); *Ceram. Abs.*, **1**, 181 (1922); *Ceram. Abs.*, **1**, 253 (1922).—Investigations of several disintegrated blast furnace linings showed the presence of varying amounts from 0.1 to 40% of ZnO absorbed in the body of the brick. It is assumed that it had combined with the alumina in the brick. Its effect, which is accumulative, is to expand and break up the bond.

148. Refractories source of troubles.

M. L. MORRISON. *Foundry*, **5** , 33–35 (1922); *Ceram. Abs.*, **1**, 209 (1922).—The blow holes in cast iron attributed to overheating may, in some cases, be caused by the decomposition by water present in the molding sand of carbides of Al and Ca formed by reactions between the melt and the refractories. Careful selection of the refractories used in the cupola lessens this damage.

149. Laboratory furnace for deformation temperature of refractories.

L. R. OFFICE. *Chem. Met. Eng.*, **25**, 162–63 (1922); *Ceram. Abs.*, **1**, 209 (1922).—A small pot furnace is described with drawings. Natural gas at 2½ lbs. and preheated air at 25–30 pounds pressure will give cone 35 in 45 minutes. The preheater and burner are the special features.

150. One-piece furnace lining.

I. S. PIETERS. *Iron and Steel of Canada*, **5**, 156 (1922); *Ceram. Abs.*, **1**, 314 (1922).—Discusses the merits of the one-piece monolithic lining for refractory furnace compared with brick lining. In the former there are no joints to cause unequal expansion and contractions, and no chemical action between the different substances. It increases the life of the furnace and also the efficiency.

151. Glass-house refractories.

W. J. REES. *Pottery Gaz.*, **47**, 727–35 (1922); *C. A.*, **17**, 2175 (1923).—Porosity should be as low as possible on account of the action of the glass when it penetrates the brick. Grog and clay should have the same degree of solubility. This is to prevent stones in the glass due to unequal solution of the brick. Recommends the use of high silica clay because of greater strength and heat conductivity. Discusses failures of tank blocks due to corrosion. Failure of tank block below the melt is due to abrasion.

152. Refractories for coke-oven construction.

W. J. REES. *Fuel*, **1**, 20–22 (1922); *C. A.*, **16**, 3751 (1922); *Ceram. Abs.*, **2**, 18 (1923).—Experiments were made upon various refractories with NaCl vapor, with and without H_2O. SiO_2 bricks were more resistant. Facing or glazing the exposed surface fails, owing to differential expansion.

153. The hardness of refractories at high temperatures.

E. RENGADE AND E. DESVIGNES. *Ceramique*, **25**, 33–37 (1922); *Ceram. Abs.*, **1**, 139 (1922); *C. A.*, **16**, 1644 (1922).—The hardness of various silica-alumina refractories was tested by heating small cubes of the material to high temperatures in a carbon resistance furnace. Description of the apparatus, chemical analysis of 9 clays, and a graph showing the depth of impression are given.

154. Chemistry and physics of gasworks refractories.

T. F. E. RHEAD. *Gas World*, **76**, 225 (1922); *Gas Jour.*, **157**, 633–36 (1922); *Ceram. Abs.*, **1**, 233 (1922).—Attention is drawn to the influences of grading, proportioning, mixing, molding, pressure, firing, etc.

155. The volatilization of silica in the manufacture of refractories in electric furnaces.

RI. *Deut. Töp. Zieg. Ztg.*, **53**, 221–22 (1922); *Ceram. Abs.*, **1**, 312 (1922).—Amorphous SiO_2 containing 99.15% hydrated silica and which deformed at cone 35 was placed in a crucible and heated in an electric furnace in an oxidizing atmosphere at cone 39. No appreciable volatilization was noticed. When this same SiO_2 was placed in coke blocks and heated in the same furnace the SiO_2 volatilized rapidly and was deposited in the cooler portions of the kiln. Similar experiments were made on a number of substances and the ingredients which volatilized determined by chemical analysis (see Table I).

I is a fusible brick clay, II a feldspar, III a second grade fire clay, IV a good fire clay, and V a highly refractory kaolin. VI, VII, and VIII are mixtures of kaolin with MgO, CaO, and K_2O. In all cases the SiO_2 volatilized more than the Al_2O_3. The alkalis volatilized more than the SiO_2. The product which condensed on the cooler portions of the kiln was composed principally of K_2O and SiO_2 with small amounts of Al_2O_3 and CaO. The volatilization of SiO_2 in a reducing atmosphere is explained by reduction of the SiO_2 which would liberate the extremely volatile Si.

156. Brickmaking in remote mining districts.

H. C. ROBSON. *Min. Sci. Press*, **142**, 187 (1922); *Ceram. Abs.*, **1**, 201 (1922).—Brickmaking in Siberia is described.

157. Load tests on refractory bodies at high temperatures.

E. SIEURIN, F. CARLSSON, AND B. KJELLGREN. *Ber. deut. keram. Ges.*, **3** [2], 53–64 (1922); *Ceram. Abs.*, **1**, 277 (1922); *C. A.* **16**, 4317 (1922).—The softening temperature under pressure of a fireclay body mixed with varying amounts of SiO_2, Al_2O_3, Fe_2O_3, CaO, and MgO is given. Seven graphs are given to show the effect of the added materials upon both the softening point and melting point.

158. Resistance tests of fire bricks under load at high temperatures.

E. SIEURIN AND F. CARLSSON. *Jour. Amer. Ceram. Soc.*, **5**, 170–80 (1922); *C. A.*, **16**, 1843 (1922).—Known amounts of SiO_2, Al_2O_3, etc., were added to mixtures of china clay, ball clay, and grog and a standard load test applied. Even very small amounts of Fe_2O_3, CaO, or MgO greatly reduced the resistance to pressure. The lowest resistance was with SiO_2 at 60–70%. Additions of Al_2O_3 increased resistance, but with high Al_2O_3 failure was caused by lack of bond.

159. Operating conditions in the open hearth as they affect the life of refractories.

C. A. SMITH. *Jour. Amer. Ceram. Soc.*, **8**, 833–38 (1922).—A discussion of the deterioration of refractories under operating conditions of the acid and basic types of open hearth furnaces is given.

160. Determination of the softening temperature of refractory materials under load.

W. STEGER. *Ber. deut. keram. Ges.*, **3**, 1–4 (1922); *Ceram. Abs.*, **2**, 52 (1923); *C. A.*, **16**, 4317 (1922).—Description of electric furnace and method used.

161. Refractories for zinc smelting.

G. C. STONE. *Jour. Amer. Ceram. Soc.*, **5**, 597–60 (1922); *C. A.*, **16**, 4037 (1922).—General requirements of refractories for roasting furnaces, oxide furnaces, spelter furnace linings, retorts and condensers are discussed. All refractories should be dense and strong.

162. On the thermal properties of refractories at high temperatures.

YOSHIAKI TADOKORA. Report of the Research Lab. Imperial Iron Works, No. 2 (1922); *Ceram. Abs.*, **2**, 159 (1923); *Trans. Ceram. Soc.* (Eng.), **22**, 114A (1923).—Description of apparatus. The progression of expansion of silica brick upon heating and cooling was noted. The same data was gathered upon reheating and cooling 3 times. Curves given. Same test run on magnesia, chrome, and grogged brick.

163. Manufacture of fireclay refractories.

A. G. WIKOFF. *Chem. Met. Eng.*, **27**, 505 (1922); *Ceram. Abs.*, **2**, 15 (1923).—An outline of plant operations at the Evens and Howard Fire Brick Co., St. Louis. Gives a description of plant layout, of raw materials used and their preparations, and of forming, drying, and firing of brick. Manufacturing operations are coördinated by the planning department to obtain maximum production efficiency.

164. Bricks for muffle furnaces.

ANON. *Brit. Clayworker*, **32**, 41 (1923); *Trans. Ceram. Soc.* (Eng.), **22**, 93A (1923).—The requisite qualities of the brick are discussed under the following heads: temperature, strength when hot, changes of temperature, corrosion, thermal conductivity, and constancy of volume.

165. Service classification of fire brick.

ANON. *Bull. Amer. Ceram. Soc.*, **2**, 263–68 (1923).—The service classification chart as adopted by Committee C-8 A.S.T.M. is given, explained, and illustrated.

166. Testing refractory materials under load.

ANON. *Gas Jour.*, **163**, 474 (1923); *Ceram. Abs.*, **4**, 107 (1925); *C. A.*, **17**, 3589 (1923).—Description of a new apparatus for determining the softening point of refractory materials under load, and also automatically and graphically recording the thermal expansion before the softening point is reached, and the subsequent contraction or compression.

167. A new refractory tester.

ANON. *Iron and Coal Trades Rev.*, **107**, 15 (1923); *Ceram. Abs.*, **2**, 223 (1923).—This instrument is an electric furnace with an apparatus so contrived that it will measure the expansion or contraction of the test piece under load while the temperature is being varied. A detailed description is given of the apparatus and some curves showing results of tests. The machine consists of several levers attached to the carbon blocks between which the test piece rests in the furnace. The load for the load test is applied to these levers and a stylus is attached which records the expansion or contraction throughout the whole load test.

168. Metallurgical requirements for refractories for use in the aluminum industry.

R. J. ANDERSON. *Jour. Amer. Ceram. Soc.*, **6**, 1090–93 (1923); *C. A.*, **17**, 3911 (1923).—Melting temperature is low but liquid aluminum is very corrosive. Carborundum and high grade fire brick are used for lining the furnaces. Alundum is unsuccessful.

169. Research on refractories in France.

V. BODIN. *Ceramique*, **26**, 200–206 (1923); *Ceram. Abs.*, **3**, 129 (1924); *C. A.*, **18**, 188 (1924).—Discusses specifications, describes tests, and gives physical data.

170. Some interesting properties of refractory materials.

B. BOGITCH. *Rev. universelle mines*, **17**, 65–80 (1923); *Ceram. Abs.*, **4**, 78 (1925); *C. A.*, **17**, 2942 (1923).—A description of the chemical and physical properties of refractory materials, including their chemical composition in relation to their fusibility, their physical properties as a function of temperature, and dilation and heat conductivity as a cause of their slow destruction.

171. Refractories for stokers.

G. I. BOUTON. *Jour. Amer. Ceram. Soc.*, **6**, 1190–93 (1923); *C. A.*, **18**, 739 (1924).—Requirements are: (1) high fusing point; (2) absence of spalling; (3) ability to stand pressure at the temperature of use; (4) resistance to fluxing action of ash.

172. Bricks used for electric furnace.

C. CAMPBELL. *Brick Pottery Trades Jour.*, **31**, 165 (1923); *Trans. Ceram. Soc* (Eng.), **22**, 92A (1923).—A short discussion of the uses of the commoner refractories in the electric furnace. The various defects of the refractories and the location of these refractories in the furnace are given. Refractories used in the electric furnace are fire bricks, half silica bricks, silica bricks, dolomite bricks, magnesite bricks, and chromite bricks.

173. Materials for furnaces and ovens.

E. F. COLLINS. *Chem. Met. Eng.*, **28,** 79 (1923); *Ceram. Abs.*, **2,** 51 (1923).—Charts and table are reproduced showing the limitations of various metals and ceramic products for furnaces, particularly electrically heated equipment. One chart showed the thermal resistance of heat insulators, refractories, and heat conductors.

174. An examination of refractories by the oxygen blow pipe.

ALGERNON L. CURTIS. *Trans. Ceram. Soc.* (Eng.), **22,** 199 (1923); *Ceram. Abs.*, **3,** 47 (1924).—It is sometimes necessary to examine quickly the refractory qualities of raw materials and to compare different materials one with another during examination. Ordinarily an ultimate chemical analysis is made first, and if satisfactory, cones of the material finely ground are made up and exposed to varying temperatures. This combination of tests is an efficient one, although the time and expense are large. To save time expose to a strong fixed blowpipe flame and study "surface attack" from heat and shrinkage by projected magnification. Those materials first affected by heat are inferior to materials which resist.

175. Outline of refractory requirements for the iron and steel industry.

F. W. DAVIS. *Jour. Amer. Ceram. Soc.*, **6,** 1183–88 (1923); *C. A.*, **18,** 739 (1924).—Gives the requirements for the refractories for the different parts of blast furnace, by-product coke oven, Bessemer converters, open hearth.

176. Refractories.

P. S. DEVEREAUX. *Jour. Birmingham Met. Soc.*, **8,** 5364 (1923); *Ceram. Abs.*, **2,** 76 (1923).—A review of the whole subject of refractories as follows: resistance to destructive agents; crushing strength; effects of loads on various fire bricks; chromite, dolomite, and magnesite refractories; higher refractories such as carborundum, fused alumina, zirconia, etc.; also standardized testing and conservation of fuel.

177. Refractory materials of the London Basin.

HENRY DEWEY. *Trans. Ceram. Soc.* (Eng.), **22,** 38 (1923); *Ceram. Abs.*, **3,** 14 (1924).—By the London Basin the geologist means that part of the S. E. of England which is practically the same as the Thames Basin. The chalk supplies very little material of a refractory nature. Of the Tertiary beds the Thanet sands supply materials used in the manufacture of lime-sand bricks, and as casting and molding sands. The most remarkable deposit consists of loamy sand of a greenish gray to white tint and varies in thickness up to 5 feet. Refractory wares, used at many of the London and other gasworks, are made from this material. The principal brick-earths form wide-spread tracts at about 90 feet and 50 feet, respectively, above sea-level. Most of the large brick fields which formerly supplied London with its building bricks were in the alluvial brick-earths.

178. Refractory materials.

H. DROUOT. *La Tech. Moderne*, **15,** Jan.–Mar. (1923); *Ceram. Abs.*, **2,** 161 (1923).—A very comprehensive summary of refractory materials, including a history of refractory industry, fabrication, properties, chemistry, diagrams showing the high temperature to which refractories may be subjected, which temperature is the determining factor of their industrial applications.

179. Tests on clays for making zinc retorts.

K. ENDELL AND W. STEGER. *Metall u. Erz*, **20,** 321–31 (1923); *Ceram. Abs.*, **3,** 269 (1924).—Tests on a number of German, Belgian, and American clays have been carried out to determine their suitability for making zinc retorts. Results of the tests are given. The tests include the chemical and rational composition, drying shrinkage, and

porosity after firing to 1000°, 1100°, 1200°, 1300° and 1450°. The higher the SiO_2 of the grog the higher the softening point. Clay containing 60–80% SiC softened 100° higher than the grog mixtures.

180. Discussion on "Refractories for oil-burning furnaces."

R. L. FRINK. *Bull. Amer. Ceram. Soc.*, **2**, 9–20 (1923).—Discussion of causes of "rotting" of fireclay brick under oil burning conditions.

181. Progress report on specifications for refractories.

R. F. GELLER. *Jour. Amer. Ceram. Soc.*, **6**, 1098–1111 (1923).—Following a conference with producers and consumers of refractories, a series of proposed laboratory tests were conducted on 41 commercial brands of brick. The work included reheating at 1450° and 1400°C, quenching, load test, fusion point determination, chemical analyses and petrographic examination. Results of tests are presented. They will be more fully discussed when correlated with service tests now under way.

182. The suitability of the tunnel kiln for firing refractories.

A. F. GREAVES-WALKER. *Jour. Amer. Ceram. Soc.*, **6**, 891–905 (1923).—This is an analytical report with operating data.

183. The manufacture of refractories in America.

A. F. GREAVES-WALKER. *Trans. Ceram. Soc.* (Eng.), **22**, 358–76 (1923); *Ceram. Abs.*, **3**, 289 (1924).—A description of American methods: The hand-made, stiff mud or steam press, soft mud, and dry press processes; drying methods, setting methods; firing methods; tunnel kilns; magnesite and chrome products; hand-made and machine-made silica products; plant equipment and organization. The English discussion centered on the size and waste space of tunnel kilns; appreciation of machinery like the discharging revolving bottom pan and poidometers; humidity driers; and the danger of hasty work incurred by allowing men to leave work early.

184. Refractories for flat arches.

J. E. HARLOW. *Jour. Amer. Ceram. Soc.*, **6**, 1195–96 (1923); *C. A.*, **18**, 739 (1924).—Fireclay tile are suspended on cast iron hangers by means of a tee-shaped slot molded in the top end of each tile, giving room for expansion in every direction. Larger quantities of heat units are released, more intense chemical reactions take place and there is ample shearing strength and small loss from weight or pressure.

185. Note on the abrasion of fireclay materials.

W. C. HANCOCK AND W. E. KING. *Trans. Ceram. Soc.* (Eng.), **22**, 317–22 (1923); *Ceram. Abs.*, **3**, 291 (1924); *C. A.*, **18**, 1372 (1924).—The apparatus permits studying abrasion at high temperature. Material with coarser grain or admixed grog suffers heavier losses. Abrasion seems to increase with temperature.

186. The value of uniform fire brick from the standpoint of the consumer.

R. F. HARRINGTON. *Jour. Amer. Ceram. Soc.*, **6**, 1193–95 (1923).—H. describes the difficulties encountered in using bricks of varied sizes and quality.

187. Technical education in relation to the refractories industry.

G. W. HEFFORD. *Trans. Ceram. Soc.* (Eng.), **22**, 205 (1923); *Ceram. Abs.*, **3**, 61 (1924).—There are undoubtedly numbers of first-rate men in the industry, so far as their experience goes, but for lack of suitable scientific training they are unable to translate the results of research into works practice. The function of research work in connection with industry is something more than the provision of foolproof tips; it is to determine principles and constants, which, by men with training, acumen, and

imagination can be applied in the circumstances of the particular works in which they are interested. An interesting attempt has just been started at Brierley Hill to provide suitable instruction in refractories; its success will be determined largely by the amount of practical support it receives from the industry, and the amount of practical sympathy the industry extends to the students.

188. Slag action on refractory linings.

H. HIRSCH. *Tonind. Ztg.*, **47**, 152–54 (1923); *Ceram. Abs.*, **2**, 131 (1923); *C. A.*, **17**, 2178 (1923).—The compositions and melting points of the 8 slags are given along with the compositions of 7 refractories and their melting points, and the effect of the actions of the slags. The action of the slag was tested by drilling a hole in the refractory and filling it with slag. It was found that the porosity of the brick was more important than the Al_2O_3 content. Some points are given on the construction of the walls.

189. Fuel and refractory lining material.

H. HIRSCH. *Keram. Rund.*, **31** [14] (1923); *Jour. Soc. Glass Tech.*, **7**, 194–95; *Ceram. Abs.*, **3**, 318 (1924); *C. A.*, **18**, 2588 (1924).—The necessity for the testing of refractory materials before use was emphasized, especial reference being made to refractory materials for boiler furnaces where the chemical action of slags was the important factor. The effect of 8 slags (chemical composition given) and method of testing the refractory is discussed. Kind of refractories used and the design of the fire box are important factors.

190. Softening of refractory materials.

H. HIRSCH AND W. PULFRICH. *Tonind. Ztg.*, **47**, 801–806 (1923); *Ceram. Abs.*, **3**, 318 (1924); *C. A.*, **18**, 2588 (1924).—The normal refractoriness and the refractoriness under load of 1 kg. sq. cm. porosity, crushing strength, expansion, and specific gravity were determined. All but one of the silica brick showed a slight expansion when heated. The odd one contained 89% SiO_2 and 5.8% Al_2O_3. It behaved like a brick made of clay and quartz. Eighteen fireclay brick when heated under a load of 2 kg. per sq. cm. retained their volume to about 1250°C and then began to contract. They did not collapse suddenly like the silica bricks but slowly lost their shape as the temperature rose, except those bricks which contained over 80% SiO_2; these bricks collapsed more suddenly, but not so rapidly as silica brick.

191. The reversible thermal expansion of refractory materials.

H. S. HOULDSWORTH AND J. W. COBB. *Jour. Amer. Ceram. Soc.*, **6**, 645–62 (1923); *C. A.*, **17**, 3589 (1923).—The reversible thermal expansion was determined for kaolin, siliceous and aluminous fire clays, quartzite, MgO and SiO_2 brick, and SiC. Kaolin and high Al_2O_3 fire clays showed regular reversible expansions which did not vary much with firing temperature. High SiO_2 clays showed marked irregularities due to quartz changes. Brick from steel furnace showed the quartz completely changed to cristobalite.

192. Testing refractories.

R. M. HOWE. *Jour. Amer. Ceram. Soc.*, **6**, 296–98.—H. gives a review with a brief list of references of progress in testing of refractories.

193. A study of the slag test.

R. M. HOWE. *Jour. Amer. Ceram. Soc.*, **6**, 466–73 (1923); *C. A.*, **17**, 1313 (1923).—Many data on the penetration method of slag testing showed little or no relation between laboratory tests and factory results. A newer method based upon the depression of the melting point of ground samples of the refractories by additions of known slags appears to give more reliable information than the old penetration tests.

194. The action of slag upon silica, magnesite, chrome, diaspore, and fireclay refractories.

R. M. Howe, S. M. Phelps, and R. F. Ferguson. *Jour. Amer. Ceram. Soc.*, **6**, 589–95 (1923); *C. A.*, **17**, 2482 (1923).—Powdered brick and powdered slag were mixed in varying proportions and the fusion points determined. Magnesite had a higher resistance to most slags than chrome. Silica and fire brick showed rather wide variations. Magnesite and chrome brick showed high resistance to basic open-hearth slag, as they do in service. Diaspore showed high resistance to all slags.

195. Ceramic and refractory materials.

C. E. Kraus. Brit. 224,257, May 1, 1923; *Ceram. Abs.*, **4**, 168 (1925).—The plasticity of ceramic materials, refractory compositions, mortars, etc., containing clay, kaolin, bauxite, flint, asbestos, $CaCO_3$ or similar ingredients is increased by the addition of 5–20% of a highly colloidal earth such as bentonite, ehrenbergite, damonterolite, or montmorillonite, with or without cork or other combustible substances which are fired out to produce porous heat-insulation.

196. Process for making refractory products.

Louis P. Kraus, Jr. U. S. 1,453,468; *Ceram. Abs.*, **2**, 162 (1923).—The method of treating refractory material consisting in roasting a ground mixture of the material and a combustible at such a clinkering temperature below its melting point as to produce a clinkered material in the form of spongy grains free from crystalline structure.

197. Study of the warpage of refractory mixtures, clays, kaolins, and porcelain when fired at different temperatures.

Marc Larcheveque. *Ceramique*, **26**, 167–80 (1923); *Ceram. Abs.*, **2**, 221 (1923); *C. A.*, **17**, 3589 (1923).—Bars were placed on knife edges and fired and the warpage measured. The warpage was much less on bars that had been previously fired than on raw bars. One part of clay and one part of sand was more resistant than one part of clay and one part of grog. Fine sand gave more resistance than coarse. Mixtures of clays seemed more resistant than single clays.

198. Refractories in the steel industry.

J. S. McDowell. *Blast Fur. and Steel Plant*, **11**, 522, 569 (1923); *Ceram. Abs.*, **3**, 75 (1924); *Trans. Ceram. Soc.* (Eng.), **23**, 46A (1924).—Physical and chemical properties of the refractories used in the blast furnace and steel industry are listed and discussed, together with some notes on the requirements for use in various parts of different types of furnaces employed in the industry.

199. Firebrick disintegration.

C. E. Nesbitt and M. L. Bell. *Brick and Clay Rec.*, **62**, 1042–43 (1923); *Ceram. Abs.*, **2**, 223 (1923); *C. A.*, **17**, 3081 (1923).—Disintegration in the linings of blast furnaces takes place 40 to 50 feet from top of furnace. Disintegration is attributed to objectionable Fe compounds. The CO in the furnace atmosphere reacts with Fe_2O_3 depositing voluminous graphitic C which bursts the brick. Reaction fairly rapid at 325–525°.

200. Solving furnace lining problems.

C. E. Nesbitt and M. L. Bell. *Iron Trade Rev.*, **72**, 602 (1923); *Trans. Ceram. Soc.* (Eng.), **23**, 19 (1924).—Brick containing 2% of iron ore was badly shattered when heated to 450°C in a CO atmosphere for 10 hours. 0.25% of ore caused fine cracking. Bricks without iron showed no disintegration. Soft-fired brick disintegrated before raw or hard-fired.

201. Metallurgical requirements for refractories in the electrothermic metallurgy of zinc.

B. M. O'HARRA. *Jour. Amer. Ceram. Soc.*, **6**, 1180–82 (1923); *C. A.*, **18**, 739 (1924). —Brick for lining electrothermic dry, distillation furnaces must have a fusing point not under 1600°, must retain their strength at 1400–1500°, must be non-porous and of uniform size. Where slag is produced the brick must also resist the corrosive action of the slag which may be either acid or basic. Brick for lining the condensers need not have a high fusion point but must be dense and very low in free Fe oxide to withstand the disintegrating action of CO in the cooler portions of the condenser.

202. The disintegration of refractory brick by carbon monoxides.

B. M. O'HARRA AND W. J. DARBY. *Jour. Amer. Ceram. Soc.*, **6**, 904–14 (1923); *C. A.*, **17**, 3765 (1923).—Particles of Fe oxide are reduced at low temperatures by the CO to Fe, thus causing trouble. C deposition is not troublesome above 750–800°. Iron-free fire brick, SiO_2 brick, SiC brick, or chrome brick, low in Fe, are not affected.

203. Technical literature on refractories.

P. L. M. *Rev. Mat. Constr. Trav. Pub.*, **164**, 93–95B, **165**, 116–18B, **166**, 137–39B, **167**, 152–58B, **168**, 177–79B, **169**, 196–97B, **170**, 215–18B, **171**, 237–39B (1923); *Ceram. Abs.*, **3**, 101 (1924).—Material on testing, analyses, data, properties, etc., for thec ommoner refractories.

204. Metallurgical requirements of refractories in copper smelting and refining.

F. R. PYNE. *Jour. Amer. Ceram. Soc.*, **6**, 1188–90 (1923); *C. A.*, **18**, 739 (1924).— The requirements include resistance to temperature, chemical action, sudden temperature changes and penetration of slag and metal.

205. Durability of refractories.

W. J. REES. *Metal. Ind.* (London), **23**, 414–15 (1923); *Ceram. Abs.*, **2**, 129 (1923); *ibid.*, **3**, 47 (1924); *Gas World* (Coking section), **78**, 19 (1923); *Trans. Ceram. Soc.* (Eng.), **22**, 53A (1923); *Jour. Roy. Soc. Arts*, **71**, 338–48 [Disc. 353] (1923); *Sci. Abs*, **26**, 367B (1923), *Coll. Guardian*, **125**, 515; *Pottery Gaz.*, 48, 453–58 (1923). – (Abstract of paper before Birmingham Met. Soc.) – The election and use of refractory materials cannot be placed on an adequate basis until physical and chemical properties can be specified and tested in measurable quantities; this necessitates a clear understanding of the conditions that the materials are called upon to meet. Failures of refractory materials are placed in 4 classes: viz., (1) unsatisfactory qualities, including lack of uniformity; (2) faulty selection; (3) faulty treatment due to accidents, carelessness or ignorance; and (4) absence of factor of safety. Failure under the first two classes should be capable of being completely eliminated and those due to faulty treatment capable of elimination to a marked extent by proper training or a bonus to operators, based on the life of refractories or pots. Durability is dependent upon 9 factors: viz., (1) softening temperature, (2) mechanical strength, (3) thermal expansion, (4) permanent expansion, (5) resistance to abrasion, (6) resistance to slagging, (7) permeability, (8) sudden temperature changes, and (9) changes in properties after prolonged heating.

206. Producer gas for firing refractories.

W. D. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **6**, 799, 807 (1923).—History of installations in the United States of producer gas for firing fire brick. Causes of failure or abandonment of producer gas firing. Continuous regenerative kiln necessary for successful firing at high temperatures with producer gas. The compartment kiln, fired with producer gas, best adapted for general refractories. Advantages of the compartment kiln over the car tunnel kiln. Essential features of continuous kilns for the success-

ful firing of refractories. Special features of gas producers for ceramic kilns. Temperatures from producer gas. Economy of producer gas as compared with natural gas, oil, and powdered coal. Investigation of designs and methods of operating gas producers.

207. Properties and testing of refractories.

R. RIEKE. *Gas u. Wasserfach.*, **66**, 33–36, 53–55, 66–68 (1923); *Ceram. Abs.*, **2**, 256 (1923); *C. A.*, **17**, 2942 (1923).

208. A proposed method for studying the attack of molten slags and glasses upon refractory materials.

C. I. ROSE. *Jour. Amer. Ceram. Soc.*, **6**, 1242–47 (1923); *C. A.*, **18**, 739 (1924).—The refractory being tested is rotated in a glass or slag melt under fixed conditions. The solution and penetration of the refractory by the glass or slag are measured separately by means of a micrometer and simple microscope.

209. The heat effect on refractory clays and their mixtures.

SHINZO SATOH. *Tokio Imp. Univ. Sci. Repts.*, **1** [3], 157–201 (1923); *Ceram. Abs.*, **4**, 75 (1925).—I. Thermal expansion and contraction. (1) Firing contraction of raw refractory clay. (2) Firing contraction of clay mixture. (3) Firing contraction at a constant temperature. II–IV. Endothermal and exothermal reaction. Determination of the dehydration point of clay and a thermo-balance; the change of the microstructure of clay by heating. V. Microstructure of stone. (1) Unfused quartz grains coming from glass pot materials. (2) Ditto coming from glass batch. (3) Clay substance coming from pot materials. (4) Insoluble foreign mineral coming from pot materials as well as glass batch.

210. Carbonization of clays.

W. SMITH. *Min. and Met.*, **4**, 606 (1923); *Ceram. Abs.*, **3**, 75 (1924).—Abstract of a paper before Refractory Materials Section of Ceramic Society of England. S. shows that by saturating clay with hydrocarbon gases or volatile hydrocarbons under pressure the gases dissociate and deposit very finely divided carbon on the particles of clay. This occurs when the clay has maximum porosity and before firing contraction has set in. Clay thus carbonized is black and when contraction takes place during heating in the final stages of firing, great pressure is exerted on the enclosed particles of carbon and a dense, hard, composite body is formed. By firing in strongly oxidizing flame this product may be converted into a microscopically porous structure, owing to burning away of the carbon, the refractory properties being highly increased. For the black carbonized clay the term "carbonite" is suggested for industrial purposes. It is refractory to heat in absence of air and resistant to acids, as well as impervious to atmospheric action. For the white clay, from which the carbon has been burned out, the term "carbo-calcined" clay is suggested. Its refractory properties are due to the artificially produced porosity and it usually does not melt at anywhere near the same temperature as the original material. The durability of carbonized brick in industrial furnaces is much greater than that of bricks made of untreated clay. Binding is accomplished by pressure, as with magnesite. Artificial binders should be used sparingly and with carbo-calcined materials the binder should preferably be of the same composition as the original clay. Carbonization increases the normal function of sillimanite. By special treatment of certain clays, the production of a brick, retort, and crucible consisting mostly of sillimanite has been accomplished on a small scale. Bricks of carbonized clay possess refractoriness and hardness and exhibit little or no contraction or expansion. See also *Ceram. Abs.*, **2**, 182 (1923).

211. Refractory possibilities of some Georgia clays.

R. T. STULL AND G. A. BOLE. *Jour. Amer. Ceram. Soc.*, **6**, 663–73 (1923); *C. A.*, **17**, 3589 (1923).—The Georgia sedimentary kaolins, bauxitic clays and bauxites tested showed fusion points of cones 34–39, good carrying capacity, and good resistance to spalling. Dry press or slush mold repress can be used. Furnace results obtained from fire brick made of Georgia sedimentary kaolin were equal or superior to fire clay and silica brick.

212. Refractory materials for the construction of furnaces.

THOMAS. *Giesserei Ztg.*, **10**, 235–37 (1923); *Ceram. Abs.*, **3**, 15 (1924); *C. A.*, **17**, 3765 (1923).—Unreliable results are obtained in the determination of the refractory quality of a material by the Seger cone method because the cone softens at much lower temperature. Far superior is the method of Endell (no reference). The valuation of materials by this method and their use in furnace construction are discussed.

213. Thermal capacity of bricks.

F. TSCHOPLOWITY. *Brit. Clayworker*, **32**, 91 (1923); *Ceram. Abs.*, **2**, 197 (1923).—The specific heat of poor conductors such as bricks may be determined without the use of expensive calorimeters as follows: A cylindrical glass tube closed at one end, without any rim and about 1½ in. diam. is provided with a rubber stopper about ½ in. thick and supports a chemical thermometer, the bulb of which extends to about ½ in. from the bottom of the tube. About 80 cc. of water is placed in the tube and the latter, with its contents, is maintained at a convenient temperature, by means of a water bath. An accurately weighed amount of material (reduced to pieces about $\frac{1}{12}$ in. diam. is heated to 100°C, until it has attained this temp. The material is then transferred rapidly to the tube, and the rise in the temperature of the contents is noted, the tube being kept in the water bath all the time. The temperature of the water bath is gradually increased by the addition of hot water, so that it becomes nearly the same as the contents of the tube. The specific heat is then found from the following formula: $C = W(a-b)/D(e-a)$. Where C = the specific heat, W = the weight of water in the tube, a the highest temperature attained by the mixture, b is the temperature of the water before adding the material to be tested, D the weight of the material, e the temperature of the hot material. Determinations made in this manner show a specific heat of 0.216 for fire brick and 0.184 for common brick as compared with 0.23, which figure is generally accepted.

214. Some observations on the corrosion of fireclay materials by alkali salts.

D. TURNER AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **7**, 207–27 (1923); *Ceram. Abs.*, **3**, 68 (1924); *C. A.*, **18**, 739 (1924).—One gram of grog was mixed with 20 g. of alkali salt and heated for 3 hours at 800°. The residue was extracted with H_2O and the grog treated with HCl to remove Al_2O_3. The solution was analyzed and the grog ignited and weighed. Large unexplainable fluctuations were found between separate tests, and the loss in weight of the grog was less than half the amount of Al_2O_3 found in the salt. Na and K carbonates and nitrates and borax attack fired clay even at 800°, borax and the nitrates having the greatest effect. K salts are more corrosive than Na salts and at 800° Na_2SO_4 has only a slight action. The rate of attack increases rapidly with increase of temperature while different clays have different resistances not directly dependent upon chemical composition. Higher firing temperature increases resistance of clay.

215. The analysis of refractories.

C. A. UNDERWOOD. *Jour. Amer. Ceram. Soc.*, **6**, 1263 (1923); *C. A.*, **18**, 738 (1924). —Full directions for the chemical analysis of silica brick, ganister, magnesite, fire clays, diaspore, bauxite, spinel, and chrome ore.

216. Constitution and microstructure of silica brick and chamotte block used in tank furnace.

ZENZIRO UNENO. *Research Lab. Asahi Glass Co.*, **10,** 67(1923); *Ceram. Abs.*, **4,** 75(1925).—I. Silica Brick: descriptions on the microstructure of typical American ganister quartzites as well as silica brick made in America and Belgium are given. (1) Quartzites of Manchuria and Korea. (2) Japanese quartzites: (*a*) Watsukamura in Yameshiro; (*b*) Bungo; (*c*) Temba and Tango; (*d*) Tosa, Awa and Izo. (3) Microstructure of domestic silica brick which have been used in a tank furnace. II. Chamotte tank blocks: (1) Tank blocks made by the Asahi Glass Co., (2) Microstructure of tank blocks made by the Asahi Co., and have been used in flux line of a tank furnace.

217. Discussion of "Causes of bulges on struck-off fireclay shapes."

E. H. VAN SCHOICK. *Bull. Amer. Ceram. Soc.*, **2,** 19–21(1923).—Causes and remedies are given of bulges or bellies upon struck-off face of fireclay shapes molded by hand in wooden molds and not repressed.

218. An investigation concerning the influence of the alkalis and alkaline earths on the fusion temperature of the different types of refractory clays.

A. S. WATTS. *Jour. Amer. Ceram. Soc.*, **6,** 1150–52(1923); *C. A.*, **18,** 738(1924).—The data shows: (1) When Al_2O_3 exceeds the ratio of 1 Al_2O_3 to 2 SiO_2 the fluxing actively increases in the order MgO, CaO, Na_2O, K_2O. (2) When SiO_2 exceeds the ratio of 1 Al_2O_3 to 2 SiO_2 the above order is reversed. (3) As SiO_2 increases, the fluxing activity of each oxide increases. (4) The increase in activity with increased amounts of flux is more pronounced when Al_2O_3 is in excess; therefore the presence of a moderate amount of fluxes is more dangerous in high Al_2O_3 than in high SiO_2 clays.

219. The transfer of heat through refractories and its determination.

A. S. WATTS AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **6,** 1075–89(1923); *C. A.*, **17,** 3911(1923).—A laboratory testing equipment is described. Comparative heat transfer values were determined as: alundun No. 1, 1.000; alundun No. 2, 0.977; Sil-O-Cel 0.263; Carbofrax B, 92% SiC, 3.39; magnesite 2.33.

220. Refractory requirements for oil refining.

A. G. WIKOFF. *Jour. Amer. Ceram. Soc.*, **6,** 1176–80(1923); *C. A.*, **18,** 739(1924).—Aside from boiler settings the main use of refractories in oil refineries is in fire still settings. With shell type stills which were used almost exclusively in the past, good No. 1 fire brick meet the requirements but some of the tube type cracking still now used, require something better.

221. Requirements of refractories for electric furnaces.

C. E. WILLIAMS. *Jour. Amer. Ceram. Soc.*, **6,** 753–60(1923).—Specialized superrefractories even at greatly increased cost, are in increasing demand. Important research developments include higher firing temperatures, the use of high Al_2O_3 clays, and increased exceptional work on fused refractories.

222. Refractory materials for the steel industry.

ANON. *Chem. Age* (Metallurgical Sec.), **10,** 10(1924); *Trans. Ceram. Soc.* (Eng.), **23,** 46A(1924).—The uses and essential properties of refractories employed in the following branches of steel works practice are discussed: (1) the open hearth, (2) basic and acid converters, (3) electric furnaces, (4) the crucible process, (5) regenerators, reheating furnaces, etc., (6) preparation of molds.

223. Comparison of steel refractories.

ANON. *Foundry*, **52,** 5(1924); *Trans. Ceram. Soc.* (Eng.), **23,** 37A(1924).—Gives differences in Seger cones as made in different countries. Brick, in one case, which

fused at cone 27 or 28 gave better service in the checkers of open-hearth regenerators than 31 or 32 cone bricks. Failure of steel furnace roofs is more often due to faulty construction than inferior brick. They used brick which were uniform in quality and size, used no mortar, took great care in keying and slackened the tierods when the furnace was fired to allow for expansion and by this overcame 90–95 % of their roof failures. This came about by preserving the original skin on the brick which glazed and protected the less refractory interior.

224. Refractories Question Box.

E. E. AYARS. *Bull. Amer. Ceram. Soc.*, **3**, 90–93, 120–24, 162–68, 228–33, 258–63, 305–11, 348–52, 392–97, 443–50 (1924).—The following topics are discussed: (1) cupola blocks; (2) effect of titanium oxide; (3) control methods; (4) effect of degree of fineness on resistance to spalling; (5) effect of sand and oil used in hand molding; (6) how to gage water content for wet pan; (7) temperature of dissociation to sillimanite and quartz; (8) effect of coal ash on refractories; (9) brick for rotary cement kiln.

225. Firing refractories in a round downdraft kiln with a mechanical stoker.

E. E. AYARS. *Jour. Amer. Ceram. Soc.*, **7**, 889–94 (1924); *C. A.*, **19**, 712 (1925).

226. Factors affecting the life of lime kiln brick linings.

J. V. AZBE. *Rock Products*, **27** [22], 30–31 (1924); *C. A.*, **19**, 566 (1925).—Reasons for failure of brick linings: (1) poor quality, fusible brick; (2) combining of brick with lime, forming fusible silicate; (3) underfiring of brick; (4) poorly laid walls: (5) spalling due to high coefficient of expansion; (6) poor kiln design, such as too great arch spans; (7) improper combustion, hot spots; (8) irregular or wrong drawing of lime; (9) kiln design and operation causing flame to sweep the sides instead of penetrating the center. Experiments might well be directed along the lines: (1) Different methods of kiln operation, drawing the lime, and firing. (2) New kiln designs, perhaps with 2 firing zones, a low and a high temperature. (3) Basic and neutral linings such as magnesite, dolomite, fused Al_2O_3, and for localized points SiC, etc. Such refractories applied by the cement gun over firebrick linings might be tried.

227. Refractory materials used in the construction of coke ovens.

V. BODIN. *Chimie et Ind.*, Special No. 415–29, May (1924); *Ceram. Abs.*, **5**, 17 (1925); *C. A.*, **18**, 3461 (1924).—A discussion of the requirements which coke-oven refractories should meet, of laboratory tests for estimating these properties, and of the qualities of various classes of materials (silica-aluminous containing less than 25 % Al_2O_3; aluminous containing 30–40 % Al_2O_3; ultra-aluminous containing over 40 % Al_2O_3; bauxite SiO_2).

228. Fireclay brick for the open hearth.

M. C. BOOZE. *Jour. Amer. Ceram. Soc.*, **7**, 686–90 (1924); *C. A.*, **18**, 3263 (1924).—Laboratory tests indicate that high Al_2O_3 brick would resist the slag action better than those higher in SiO_2.

229. Some aspects of the industrial application of refractories.

M. C. BOOZE. *Ceramist*, **4**, 243 (1924); *Ceram. Abs.*, **3**, 350 (1924).—A résumé of the character and uses of the principal types of refractories.

230. Common sense and common refractories.

M. C. BOOZE. *Chem. Met. Eng.*, **31**, 1003–5 (1924); *Ceram. Abs.*, **4**, 107 (1925); *Sci. Abs.*, **28**, 188 (1925).—No marked increase in quality can be expected in fire clay or silica refractories. The only improvement to be looked for is a greater uniformity.

231. The effect of coal ash on refractories.

J. J. BRENNAN. *Combustion*, **10**, 418–22 (1924); *Ceram. Abs.*, **3**, 289 (1924); *C. A.*, **18**, 2236 (1924).—The metallurgical point of view is adopted, wherein the ash from the coal and the furnace lining are compared to a smelter charge and lining. Chemical analyses are given of 9 coals and their ashes and 14 bricks, Fe free. Mixtures of 70% ground fire brick and 30% coal ash were prepared, each brick in combination with each ash, and molded into cones, inclined at a 45° angle with the horizontal. These were fired, along with cones of pure ash and brick to 3000°F in 4 hours. The condition of the cones was observed at 20° intervals. The temperature of initial deformation, i.e., when the tip assumed a horizontal position, was noted and the results plotted. In the majority of cases actual life of furnace linings followed closely the indications of the charts.

232. Investigation of fire brick for use in gas manufacture.

C. C. BROWN. *Gas Age-Rec.*, **54**, 549 (1924); *Ceram. Abs.*, **4**, 41 (1925).—An investigation of fire brick for the rate of heat absorbed in a certain length of time was reported and tests were made on silica, magnesite, Carborundum, clay, and Sil-O-Cel for use in regenerators. Formulas for calculating the heat absorbed were brought out and the experimental results checked fairly well. Curves plotted of the results for various thickness of bricks as to the rate of absorption are given.

233. Saving the surface of refractories by using a refractory coating.

H. M. CHRISTMAN. *Ceramist*, **4**, 107 (1924); *Ceram. Abs.*, **4**, 350 (1924).—A refractory coating is not identical with refractory cement. It is proposed to apply a superficial coating which will reduce the erosion and corrosion of refractories. Neither composition nor data are given.

234. Intrinsic value of refractory coating.

H. M. CHRISTMAN. *Fuels and Fur.*, **2**, 71–72 (1924); *C. A.*, **18**, 739 (1924).—A brief discussion of the factors which affect the life and efficiency of a refractory.

235. Some considerations necessary in selection of refractories for the open hearth.

S. CORNELL. *Jour. Amer. Ceram. Soc.*, **7**, 670–81 (1924).—The kind, quality, and quantity of refractory brick used in steel furnaces, coke ovens, blast furnaces, open hearth, and auxiliaries are discussed. The factors that influence the life of refractory brick in the open hearth furnaces, discussed numerically, with the economic situation indicated in monetary values.

236. Observations on requirements of refractories for open hearth.

F. W. DAVIS AND G. A. BOLE. *Trans. Amer. Inst. Min. Met. Eng.*, **70**, 186–200 (1924); *Ceram. Abs.*, **4**, 77 (1925); *C. A.*, **18**, 1557 (1924).—Magnesite and other refractories are considered in regard to their deterioration in service.

237. Pyrometric test of refractory clays.

F. J. A. DEJARDIN. *Rev. universelle mines*, **2**, 47–55 (1924); *Ceram. Abs.*, **3**, 318 (1924); *C. A.*, **18**, 2588 (1924).—A procedure is described for testing clays by the Seger cone method, which is claimed to be particularly reliable.

238. Testing the life of refractory products. I.

P. DEMASURE. *Bull. fed. ind. chem. Belg.*, **3**, 182–93 (1924); *C. A.*, **18**, 1887 (1924).—Some of the factors influencing the melting point and life of refractories are discussed. Recommends a fusion point test.

239. The study of refractory products. II.

P. DEMASURE. *Bull. fed. ind. chem. Belg.*, **3**, 238–56 (1924); *Ceram. Abs.*, **3**, 290 (1924); *C. A.*, **18**, 2063 (1924).—A review and discussion of the strength of various

refractories, particularly at high temperature, and description of an apparatus for measuring their compressive strengths at temperatures up to 1500°C.

240. Refractories materials. Fire clays, analyses, and physical tests.

F. R. ENNOS AND A. SCOTT. Mem. Geol. Surv., *Special Reports on the Mineral Resources of Great Britain*, **28**, 1–81 (1924); *Ceram. Abs.*, **4**, 17, 41 (1925); *C. A.*, **18**, 3692 (1924).—Refractory materials, fire clays, analyses, and physical tests. Occurrence and distribution of British fireclay refractories are described. Chemical and mineralogical composition discussed with changes during firing and the effect of impurities on properties. Methods of analysis employed and analyses of chemical composition of fire clays given. Physical tests on fire clays, methods of testing, and results of tests are given. Analyses of refractoriness in relation to chemical composition, physical tests, effect of load on refractoriness, firing, relation of porosity, and contraction are discussed.

241. Refractory linings.

W. H. GAYLORD, JR. *Oil and Gas News*, **14** [2], 24–28 (1924); *Ceram. Abs.*, **4**, 17 (1925); *C. A.*, **18**, 3461 (1924).—The use of high-temperature cement in place of fire clay in building furnace linings enables the brick to be laid out with a very thin joint and the wall bounded throughout its entire thickness at atmosphere temperatures. It is desirable to give the entire inner surface of the brick work a coating of this cement which prevents attack of the brick by flame and hot gases. Details of furnace construction and reconstruction and the use of insulating brick are discussed.

242. Best results secured by using fire brick of uniform thickness.

M. S. GEREND. *Power*, **59**, 831 (1924); *Ceram. Abs.*, **3**, 246 (1924).—The advantages to be obtained by the use of fire brick of uniform dimensions are outlined. Drawings are given illustrating two types of calipers for use in sorting out brick of any special dimension.

243. The scorification of refractory materials.

P. GILARD. *Rev. universelle mines*, **18**, 315; *C. A.*, **18**, 315 (1924).—A review and discussion of the work of Howe, Phelps, and Ferguson.

244. The electric brass furnace refractory situation.

H. W. GILLETTE AND E. L. MACK. *Jour. Amer. Ceram. Soc.*, **7**, 288–99 (1924); *C. A.*, **18**, 3262 (1924).—Since metal penetration is very important something might be done by the application of electrically fused or otherwise fully pre-shrunk refractories, selection of refractories for low thermal expansion, and especially in the use of different sizes of grain so as to minimize voids and favor close packing of the material.

245. Influence of texture on the transmission of heat through fire brick.

A. T. GREEN. *Gas Jour. Suppl.*, 31–36, July 9, 1924; *Trans. Ceram. Soc.* (Eng.), **23**, 253–70 (1924); *Ceram. Abs.*, **4**, 134 (1925); *C. A.*, **19**, 3357 (1925).—Bricks were prepared with varying percentages of grog and the true and apparent specific gravity, porosity, and crushing strength determined. The thermal conductivity increases with increased temperature of firing at temperatures below 1000°C, the bricks with lowest porosity having the greatest thermal conductivity. At high temperatures the transmission of heat by convection and radiation in the pore spaces increases, so that the conductivity of high grog bricks having the continuity of the solid material interrupted by grog increases more rapidly than that of the low-grog bricks.

246. Requirements in fire brick for lime kiln arches and linings.

W. L. HAMILTON. *Trans. 10th Ann. Meeting of the Natl. Line Mfgrs. Assoc.*, pp. 128–36 (1924).—Magnesite and chrome brick, owing to their cost and inability to

withstand changes in temperature are inapplicable, choice being restricted to refractory clays composed of plastic clays to give hardness and resistance to mechanical wear and flint clays to give refractoriness. Where temperatures are maintained above 800–900° with little variation as in continuous kilns SiO_2 bricks have proven very satisfactory.

247. Roof brick for the open hearth.

H. C. HARRISON. *Jour. Amer. Ceram. Soc.*, **7**, 698–705; (1924); *C. A.*, **18**, 3263 (1924).—The conditions under which a roof brick has to stand are considered and possible means of improving refractories in common use suggested. A brief mention is made of the possibility of utilizing other available refractories.

248. Interesting facts about refractories. A discussion of their manufacture and properties.

F. A. HARVEY. *Fuels and Fur.*, **2** [4], 335; [5], 455; [6], 559; [7], 669; [8], 765 (1924); *Ceram. Abs.*, **4**, 134 (1925).—I. Silica Brick. Sources, material, composition, manufacturing properties, density, melting point, strength, porosity, specific heat, thermal conductivity, and expansion. Difference between permanent and reversible expansion. II. Fireclay brick. Same as I but adds slag action, spalling, and abrasion. III. Silica, fire clay, and special cements. Danger of adding too much fire clay to ground silica bats. Methods of raising fusion points, cement composition. Use of "blackstrap" molasses in obtaining hard cement. IV. Magnesite, silicon carbide, alundum, dolomite, diatomaceous earth, zirconia, and aluminous refractories. Manufacture and properties. V. Testing refractories. Three classes of failures and suitable tests. Discusses sampling, inspecting, judging silica brick and shapes, volume changes on reheating, melting point, density, load test, crushing, and modulus of rupture, spalling, slagging, abrasion, conductivity, fineness, and plasticity.

249. A refractory under-load testing machine.

H. HECHT. *Tonind. Ztg.*, **48**, 109 (1924); *Trans. Ceram. Soc.* (Eng.), **23**, 47A (1924).—The broad principle of the machine is as follows: The rod, by which the load is applied, is supported by ropes passing over 2 pulleys, and counter-balanced. Preparatory to carrying out a test, this rod is centered vertically over the tube of an ordinary electric furnace. To apply a given load to the test piece, the required number of counter weights can be detached mechanically from the plate supporting the rod. The machine has been constructed in the Testing Machine Department of the Chemistry Laboratory for the Clay Industry (H. Seger and E. Cramer) of Berlin. Advantages claimed for the machine: (1) All possibility of any change taking place in the load applied and in the frictional element during the test, is eliminated. (2) Load applied can be adjusted exactly to the conditions of the test. (3) The load is applied vertically from above and can be maintained absolutely constant throughout the test independent of any expansion due to the heating of the apparatus, or of any part thereof. (4) For each test it is possible to determine not only the exact load to be applied, but also to restrict the collapse of the test piece to any desired extent, so that complete destruction of the sample can be avoided. (5) The machine is movable and can be used to run any number of tests daily by having the required number of furnaces.

250. The electrical resistivity of refractories.

A. V. HENRY. *Jour. Amer. Ceram. Soc.*, **7**, 764–82 (1924); *C. A.*, **18**, 3460 (1924).—Tests were made in an atmosphere of N, by the Wheatstone-bridge method, with a 45 V, 1000-cycle alternating current. Tables for flint fire clay, kaolin, SiO_2, sillimanite, magnesite, Maryland talc, Indian talc, and diaspore show the electrical resistivity in ohms per cm. from 300 to 1500°.

251. Conductivity and specific heat of refractories at high temperature.

M. D. HERSEY AND E. W. BUTZLER. Bur. Mines, *Repts. of Investigations*, **2564,** 7(1924); *C. A.*, **18,** 889(1924); *Ceram. Abs.*, **3,** 269(1924).—The independent tests on Central of Georgia fire brick gave conductivity figures at 250° 0.00193; at 370° 0.00187; at 910° 0.00263 calories per second per sq. cm. per 1° for 1 cm. thickness. Average specific heat of the same brick was 0–700°, 0.25–, 0–1000°, 0.262 calories per g. per 1°. Uses of the data are illustrated.

252. Determination of thermal conductivity of refractories.

M. HERSEY AND E. BUTZLER. *Jour. Wash. Acad. Sci.*, **14,** 147(1924); *Ceram. Abs.*, **3,** 220(1924).—Formulas are given to determine the heat flowing through a wall.

253. The softening temperature of fire brick.

H. HIRSCH AND M. PULFRICH. *Brit. Clayworker*, **33,** 112(1924); *Ceram. Abs.*, **3** [11], 319(1924).—Silica brick do not deform out of shape under load until 1300°C is reached. Some of the purer brick do not deform until 1500–1700°C is reached. The first signs of softening of fire brick is evident between 1130° and 1390°C and the rapid collapse is between 1370 and 1700°. Magnesite brick begin to soften under load at 1430°C and 1625°C. The difference in temperature between the commencement of softening and complete collapse is between 50 and 80°C.

254. Selection factors in choosing refractories for industrial plant use.

O. A. HOUGEN. *Chem. Met. Eng.*, **30,** 737–41(1924); *Ceram. Abs.*, **3,** 246(1924); *Sprech.*, **57,** 627–28(1924); *C. A.*, **18,** 2588 (1924).—Contains a table giving the physical and chemical properties of 23 different refractory materials. These properties are material, composition, resistance to basic fluxes, resistance to acid fluxes, resistance to oxidation and reducing conditions, resistance to molten metals, softening point, fusion point, deformation under load, coefficient of expansion, resistance to spalling, apparent density, true specific gravity, thermal conductivity, electrical resistance, hardness, resistance to abrasion, specific heat, total emissivity, and index of refraction.

255. The behavior of fire clays, bauxites, etc., on heating. II.

H. S. HOULDSWORTH AND J. W. COBB. *Trans. Ceram. Soc.* (Eng.), **23,** 111–37, 344–48(1924); *Ceram. Abs.*, **3,** 296(1924); *C. A.*, **18,** 1373(1924).—Various English clays and other hydrous aluminous minerals are observed for changes in heat absorption, volume, weight, specific gravity, porosity, and refractive index during heating. Results are given.

256. Notes on the behavior of refractories in glass melting furnaces.

H. INSLEY. *Jour. Amer. Ceram. Soc.*, **7,** 583–93(1924); *Trans. Ceram. Soc.* (Eng.), **23,** 66A(1924); *C. A.*, **18,** 3259(1924).—The paper gives the results of macroscopic and microscopic examination of refractories after service in a soda-lime glass furnace. He discusses the formation of corundum below the glass line and recommends a high alumina refractory for this part of the furnace. Silica refractories are recommended for use above the glass line where sodium compounds are present. The mortar used between the silica and the aluminous refractories should be carefully selected.

257. The transverse strength of refractory clays.

M. LARCHEVEQUE. *Brit. Clayworker*, **32,** 293(1924); *C. A.*, **18,** 1887(1924); *Ceram. Abs.*, **3,** 136(1924).—Fire clays, china clay, porcelain bodies, etc., all bend much more in the raw state than in the fired state. A clay mixed with grog bends more than the same clay mixed with sand. The clay which bends least when mixed with grog also bends least when mixed with other non-plastic materials. The cohesion of clays examined both in the raw and fired state, was greater with mixtures of clay and sand than with clay alone.

258. Some considerations necessary in the selection of refractories for the open hearth.

D. A. LYON, ET. AL. *Jour. Amer. Ceram. Soc.*, **7**, 705–16 (1924); *C. A.*, **18**, 3262 (1924).—A symposium.

259. Studies on the thermal conductivities of some refractory materials.

NORTON RESEARCH LAB. *Jour. Amer. Ceram. Soc.*, **7**, 19–28 (1924); *Trans. Ceram. Soc.* (Eng.), **23**, 72A (1924); *C. A.*, **18**, 1040 (1924).—The method used was a modification of that described by Hepplewhite. The changes made were for the purpose of insuring greater accuracy. An effective means for preventing lateral flow of heat was devised. The coefficients obtained for the several materials studied were (c.g.s. units) silica brick 0.00099, fireclay brick 0.00169, fireclay slab 0.00203, light weight fireclay brick 0.00251, sillimanite brick 0.00432, electrically sintered magnesia brick 0.00655, "alundum" fire brick 0.00833, "crystolon" silicon-carbide brick 0.00982. (The work for this paper including the design, erection, and operation of the apparatus, most of the calculations and the preparation of the detailed report was done by O. S. Buckner.) See discussion by J. S. McDowell, *Bull. Amer. Ceram. Soc.*, **3**, 345–46 (1924).

260. Process of making refractory shapes.

C. L. NORTON. U. S. 1,484,735, Feb. 26, 1924; *Ceram. Abs.*, **3**, 130 (1924).—That process of making molded shapes from granular material which comprises molding such a shape upon a pallet plate by forcibly projecting, as by dropping an unrestrained mass of such material in the form of a dense swarm of discrete particles into a mold-box resting upon such plate, and removing the mold-box to leave the molded shape upon said plate.

261. A quantitative laboratory slag test.

F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **7**, 599 (1924); *Trans. Ceram. Soc.* (Eng.), **23**, 72A (1924).—In this slag test the powdered slag is introduced into the air line of the burner, from which it is carried down into the test furnace with the flame forming an even, constantly renewed coating over the test pieces. The latter are supported on a disk and the molten slag is allowed to flow out through the bottom of the furnace. The volume of each specimen is measured before and after the test. Curves showing the per cent of each specimen remaining after a test, plotted against temperature, indicate that, on the whole, the results agree fairly closely with the behavior of the bricks in practice.

262. The method of selecting refractories for marine purposes of the Navy.

H. H. NORTON AND R. L. PORTER. *Jour. Amer. Ceram. Soc.*, **7**, 575–82 (1924); *C. A.*, **18**, 3262 (1924).—The brick must show about 54 % SiO_2, 41 % Al_2O_3, not over 5 % fluxes, and a fusing point not under cone 29. They must also pass under a simulative service test in a small oil burning furnace which ends in a spalling test wherein cold air at high velocity is blown into the hot furnace. Of 95 brands tested, only 28 passed. Considering the best 17 brands, the fusing point was cones 29–33, average 31; the SiO_2 averaged 51, the Al_2O_3 42, the TiO_2 2.5 and fluxes 4.5 %; the weight of 9-inch brick was 7.02–8.15 lbs. The SiO_2 varied from 60 to 39 %.

263. Action of blast furnace and open-hearth slags on fire brick and on silica and magnesite bricks.

J. PRELLER AND V. KORBER. *Chem. Listy*, **18**, 383–89 (1924); *Jour. Soc. Chem. Ind.*, **44B**, 173 (1925); *Ceram. Abs.*, **4**, 166 (1925); *C. A.*, **19**, 2869 (1925).—Corrosion is increased by a rise in the proportions of free FeO and MnO in the slag, by a decrease in the viscosity of the slag, and by an increase in free silica in the brick. Severity of

corrosion is inversely proportional to the density of the brick and to the amount of sillimanite formed in the parts of the lining in contact with the slag.

264. Properties required of refractories for heat treating furnaces.

E. B. PRENTICE. *Fuels and Fur.*, **2** [3], 283(1924); *Ceram. Abs.*, **3**, 246(1924).—Methods of securing best results from the furnaces is by careful selection of the best refractory for certain parts of the furnace.

265. Comparative tests of porosity and specific gravity on different types of refractory brick.

E. E. PRESSLER. *Jour. Amer. Ceram. Soc.*, **7**, 447–51(1924); *C. A.*, **18**, 3262(1924).—A more accurate measurement of open pore spaces in brick was obtained by the air expansion method than by water absorption. In some types of refractory bricks no sealed pores exist.

266. Furnace linings.

G. B. RANDALL. *Power*, **6** , 146(1924); *Ceram. Abs.*, **3**, 288(1924).—The refractory material, bonding agent, and method of application are the 3 most important elements of a furnace job. Arches and walls made of fire brick of uniform dimensions and laid up without bonding agents are emphasized. Photographs are shown of furnace walls which have been laid up with thick joints, the bonding agent running high in ground fire brick; and photographs of walls re-lined by use of a cement gun.

267. Refractories in 1924.

W. J. REES. *Ann. Rept. Soc. Chem. Ind.*, **9**, 284–92(1924); *Ceram. Abs.*, **4**, 167 (1925).—Green (*Gas Jour. Supp.*, July 9, p. 31(1924)) discusses the effect of temperature, porosity, and grog on thermal conductivity. Hallimond discussed the formation of eutectics and similar structures in slags and silicate melts. Mellor discussed difficulty in getting a relationship between composition, texture, normal refractories, and refractories under load. Dale discussed the relation of grog content to failure under load. Large deposits of sillimanite in India. Mentions spinel refractories in this country with the melting point at cone 38.

268. Alumina-silica minerals in glasshouse pots and tank blocks.

W. J. REES. *Jour. Soc. Glass Tech.*, **8**, 277–83(1924); *Pottery Gaz.*, **49** [567], 1518 (1924); *C. A.*, **19**, 1183(1925).—When finely powdered samples of glasshouse pots and tank blocks were treated for 12 hours or more with cold H_2F_2 the crystalline residues agreed very well in composition with mullite ($3Al_2O_3.2SiO_2$). The proportion of mullite present in fired clay increases with the Al_2O_3 content of the clay and with the temperature and duration of heat treatment.

269. British comments on lime kiln refractories.

A. B. SEARLE. *Rock Products*, **28**, 49–50(1924); *Ceram. Abs.*, **4**, 220(1925).—The chief actions to which the refractory of a lime kiln is subjected are: (1) abrasion of descending charge of stone and lime, (2) sudden changes of temperature, (3) chemical action of the fuel, (4) chemical action of the lime. Paving bricks, hard fine-textured firebrick, granite, and steel plate are used in the uppermost 6 foot zone. In the fire zone, high alumina fire brick are most satisfactory in resisting the chemical action of the lime. Silica brick, although used are not satisfactory. Magnesia brick do not withstand the temperature changes nor the resistance of abrasion. Rammed and tamped linings are not durable. Block are preferred to brick as there are fewer joints. Insulation saves fuel but increases temperature of hot zone.

270. Combustion in kilns firing refractory ware.

RALPH A. SHERMAN. *Jour. Amer. Ceram. Soc.*, **7**, 175–8821924).—The results are presented of a study of the process of combustion in kilns firing refractory wares, using

coal as fuel. The work was undertaken in connection with the investigation of firing problems in the manufacture of refractories, conducted by the Bureau of Mines in coöperation with the Refractories Manufacturers Association.

271. Refractory materials for constructing hearths and coke ovens.

W. SOHERR. *Glückauf*, **60**, 1055–63(1924); *Ceram. Abs.*, **4**, 135(1925); *C. A.*, **19**, 1039(1925).—A review of the physical chemistry of the behavior of refractories including the system CaO–SiO_2–Al_2O_3, which in itself suffices to explain the behavior of most materials. Silica stone, prepared by adding milk of lime to quartzite, shows in the form of thin sections, the individual metamorphic forms of silicic acid, quartz, tridymite, and cristobalite. By this means the quality of the stone can be judged.

272. Refractories products.

I. J. M. TEUNISSEN. *Het. Gas.*, **43**, 276–82, 323–27, 251–55(1924); *Ceram. Abs.*, **3**, 290(1924).—A review on the material used for molding fire bricks, their methods of preparation, and their application in the industry.

273. The firing of refractory products in France.

R. V. WIDEMANN. *Jour. Amer. Ceram. Soc.*, **7**, 29–33(1924).—Importance of the question for a country where fuel is expensive and resources are less than consumption. Types of kilns used were principally continuous kilns; some intermittent ones and a few tunnel kilns. Heating direct or with gas—evolution of ideas. Conclusion: Heating in modern kilns consists in transporting calories from one point to another with the minimum of loss, the hearth serves only to compensate these losses while raising the calories to a higher potential. The firing of refractory products can be considered either from the purely technical point of view of the influence of the firing temperature on the quality of final product, or from the economic point of view of obtaining this firing temperature in the least onerous manner. The fuel question plays an important part in the ceramic industry, particularly in the making of refractories; it is one of the important elements in cost of production, especially in a country like France in the present situation. Our production of coal in 1913 amounted, in round numbers, to 40 million tons; in 1921 due to our coal mines having been destroyed, the extraction was only 28 million tons. In 1920, although our needs amounted to 80 million tons, we were able to obtain, both in France and foreign coals, not more than 50 million tons. The saving of fuel, undertaken in all of the great nations, presented then and still presents to our country a primordial interest. The point of these various statements is to show very briefly the technic of firing in the industry of refractory products in France and the evolution of ideas in respect to firing.

274. Operating conditions in the open hearth as they affect refractories.

C. E. WILLIAMS. *Jour. Amer. Ceram. Soc.*, **7**, 681–86(1924); *C. A.*, **18**, 3263(1924).—Acid and basic practices and refractory requirements are briefly recited, but the principal consideration is given to basic open hearth. Data are given on temperatures, loads, slagging, spalling, and breaking. Refractories and conditions to be withstood in regenerators and slag pockets are described.

275. The effect of salty coal upon refractory materials.

L. M. WILSON. *Trans. Ceram. Soc.* (Eng.), **23**, 39–50(1924); *Ceram. Abs.*, **3**, 288(1924); *C. A.*, **18**, 579(1924).—The effect of NH_4Cl on fire clay and SiO_2 brick was studied. Conclusions: (1) Confirm observations by J. W. Cobb that solids interact at temperatures below the fusing point of either. (2) There is a critical temperature of 900°C where the chemical properties of fired fire clay seem to undergo a change quite apart from the critical temperature where the physical properties of either raw or fired

materials are known to alter. (3) Silica refractories are superior to fireclay refractories in resistance to salty coal. (4) At temperature between 700 and 900°C NH_4Cl removes iron and alumina from fireclay bricks or iron, alumina, and calcium from silica bricks.

276. High temperature load and fusion tests of fire brick from the Pacific Northwest in comparison with other well-known fire brick.

HEWITT WILSON. *Jour. Amer. Ceram. Soc.*, **7** [1], 34–51 (1924).—A method is suggested for testing superrefractory material under load at high temperatures similar to the standard load test for fireclay and silica brick except that the temperatures are measured by cones and are raised until 10% linear deformation of the brick is obtained. The rate of heating and soaking varies with the brick under test, and the principles learned from the cone fusion test are used in the application of heat. A numerical value, expressing the area under the cone-shrinkage curve, affords an easy method for comparing the high temperature load resistance of various refractories. The brick which are best able to resist deformation at high temperatures are composed of crystalline materials which have developed a recrystallized bond of the same composition.

277. Unusual processes in dry pressing fire brick.

ANON. *Brick and Clay Rec.*, **66**, 904 (1925); *Ceram. Abs.*, **4**, 344 (1925).—Research and repeated plant experiments by the Niles (Ohio) Firebrick Co., solved the problems of dry pressing fire brick.

278. They make no second grade ware.

ANON. *Brick and Clay Rec.*, **67**, 191 (1925); *Ceram. Abs.*, **4**, 344 (1925).—An account of the Massillon (Ohio) Stone and Fire Brick Co.

279. The color-tint test for refractories.

ANON. *Chem. Age*, **13**, 316 (1925); *Ceram. Abs.*, **4**, 311 (1925).—The specimen after cleaning is boiled in a solution of equal parts of strong HCl and saturated $AlCl_3$. After cooling it is thoroughly washed in water and then treated for half an hour with a concentrated solution of methylene blue. After washing the tint effect which gradually fades away is observed. The differential tinting produced varies, it is said, with the firing temperature of the brick, their different constituents, and the impurities present. The quartz transformation phases are also revealed by this method.

280. The development of the German refractories industry since 1871 and its present status.

ANON. *Tonind. Ztg.*, **49**, 589 (1925); *Ceram. Abs.*, **4**, 252 (1925).—Gives statistics of production and exports.

281. A tentative plan for investigating lime kiln refractories.

V. J. AZBE. *Rock Products*, **28**, 55 (1925); *C. A.*, **19**, 1480 (1925).—Outline of a plan of coöperative research.

282. Method for the analysis of aluminous silicate refractories.

E. P. BARRETT AND F. W. SCHROEDER. *Jour. Amer. Ceram. Soc.*, **8**, 69–71 (1925); *C. A.*, **19**, 1039 (1925).—Two fusions are made, (1) in Na_2CO_3 and (2) in $KHSO_4$. The melt is dissolved in water and after addition of sulphuric acid is evaporated to dense fumes. Any calcium sulphate formed must be removed. The final residue is treated with HF and H_2SO_4. The Al_2O_3 is determined by the Blum method.

283. Making refractory articles and the like.

A. G. BETTS. U. S. 1,533,689 (April 14); *Ceram. Abs.*, **4**, 168 (1925).—Process of making a refractory article which consists in molding comminuted refractory acid-insoluble material with an aqueous aluminium salt, in a metal mold, heating mold and contents, driving off volatile matters, forming the contained mix to a solid physically dry article, and separating the same from the mold.

284. Classification of refractories.

V. Bodin. *Ceramique*, **27**, 1–8 (1925); *Ceram. Abs.*, **4**, 106 (1925); *C. A.*, **19**, 1934 (1925).—B. described several methods of classifying refractories. His load test classification (temperature at which the brick squatted under a load of 10 kg. per sq. cm.) is given.

285. Research possibilities in refractories.

M. C. Booze. *Brick and Clay Rec.*, **66**, 294–96 (1925); *Ceram. Abs.*, **4**, 166 (1925).—This article deals with the methods of improving the quality and reducing the production costs of refractories. The following problems for investigation discussed: labor saving devices; miscellaneous plant equipment; auger machines and dies; method of controlling water at pug mill or wet pan; drying; firing; calcining; control of size; and purification of clays.

286. The effect of red hearts in fireclay brick.

M. C. Booze. *Jour. Amer. Ceram. Soc.*, **8**, 227–31 (1925); *C. A.*, **19**, 1762 (1925).—Laboratory tests made on 2 brands showed that red-colored fire brick, usually considered objectionable, are really superior in strength, both hot and cold. They are not suitable, however, in furnaces operated at low temperatures in which resistance to spalling is important. There is no difference in the iron content of the colored and outer zones.

287. A study of the factors involved in the spalling of fireclay refractories with some notes on the load and reheating tests and the effect of the grind on shrinkage.

M. C. Booze and S. M. Phelps. *Jour. Amer. Ceram. Soc.*, **8**, 361–82 (1925); *C. A.*, **19**, 3153 (1925).—Elasticity affects spalling much more than does coefficient of expansion or rate of temperature change. Plastic deformation was found as low as 635°; this gives the effect of elasticity and undoubtedly has considerable influence on spalling at high temperatures. The importance of hard firing is shown by load tests. The secondary expansion of brick containing Pennsylvania flint clay is influenced by the temperature of reheating, as well as the rate. Fineness of grind tests show the importance of accurate control.

288. Refractory classification and characteristics.

H. W. Brooks. *Brick and Clay Rec.*, **66**, 763 (1925); reprinted from *Power*; *Ceram. Abs.*, **4**, 344 (1925).—A classification of the well known refractories and the principal considerations governing correct refractory applications.

289. Boiler furnaces for pulverized coal.

A. G. Christie. *Mech. Eng.*, **47**, 732 (1925); *Ceram. Abs.*, **4**, 344 (1925).—An analysis of the fundamentals of the combustion of pulverized coal indicates that the following conditions are desirable for the highest efficiency and maximum capacity of a given furnace. The coal should be finely ground, thoroughly dried, and preheated. Turbulence should exist inside the furnace. The walls should be water-cooled. Among the topics discussed are methods of heat transfer, nature of combustion, furnace walls, air preheaters, coal driers, and ash.

290. Refractory brick.

Walter Crow and J. C. Schaffer. U. S. 1,553,143, Sept. 8, 1925; *Ceram. Abs.*, **4**, 312 (1925).—A refractory body comprising a chemically stabilized body-forming refractory sintered material and a humid heat sintered binder for the material coacting in the formed body not to detract from material refractory properties and leaving the body superficially sealed and the interior unclinkered.

291. The relation between under-load refractoriness, ordinary refractoriness, and composition, physical and chemical, of refractory materials.

A. J. DALE. *Trans. Ceram. Soc.* (Eng.), **24,** 170–98 (1925); *Gas Jour. Suppl.*, **171,** 14–23 (1925); *Ceram. Abs.*, **4,** 309 (1925).—A.S.T.M. load test used. Determined the effect of grog on 16 commercial bricks and 6 experimental mixtures, also the effect of texture and porosity.

292. An investigation of the effects of load, temperature, and time on deformation of firebrick material at high temperatures.

A. J. DALE. *Trans. Ceram. Soc.* (Eng.), **24,** 199–215 (1925); *Gas Jour.*, **171,** 41–45 (1925); *Ceram. Abs.*, **4,** 310 (1925); *Jour. Soc. Chem. Ind.*, **44B,** 717 (1925).—The flow of firebrick material under the stress at temperatures within the subsidence range is qualitatively analogous with the stress flow relations of "plastic" materials at ordinary temperatures and a yield load range flow exists at a given temperature with the subsidence range. At loads below the yield load range, flow under stress is probably viscosity effect. The higher the temperature the lower is the value of the yield load. Providing a certain temperature is exceeded the deformation-temperature relation is an exponential one. Below this temperature the deformation-temperature relation is a linear one.

293. Adaptation of tunnel and car kilns on firing refractories.

P. DRESSLER. *Jour. Amer. Ceram. Soc.*, **8,** 43–54 (1925).—The success of tunnel kilns in a given industry is largely determined by the choice of the type best suited to the requirements of that industry. This paper discusses the adaptation of the various types of tunnel kilns to firing glass house refractories, clay, fire brick, and silica brick.

294. Refractory materials.

V. C. FAULKNER. *Chem. Age*, **12,** 179 (1925); *Ceram. Abs.*, **4,** 167 (1925).—(1) High fusion point, apart from chemical properties, is not the criterion of refractories. (2) The heat of conductivity is equally important. (3) Plastic refractories should be used with refractories of better heat conducting properties. (4) Cementing materials should be kept to a minimum by dimensional accuracy. (5) Both mass and local pressure on brickwork should be kept to a minimum. (6) Refractory walls should be twice coated with a refractory cement and a fine finish obtained so as to obtain a glaze with object of (*a*) exposing a minimum surface to light and heat rays, (*b*) a material under no real pressure. (7) British silica brick are not fired at sufficiently high temperature; result is, they expand too much on heating.

295. An investigation of the changes taking place during the industrial firing of fireclay bricks.

A. T. GREEN AND L. S. THEOBALD. *Trans. Ceram. Soc.* (Eng.), **24,** 124–58 (1925); *Ceram. Abs.*, **4,** 346 (1925).—Samples of fire brick were withdrawn from 4 kilns at various stages during the firing and data concerning them determined. The true specific gravity indicates the change in the kaolinite molecule from 450–570°, the polymerization of the alumina molecule at about 950°C, and the vitrification range. The volume contraction determinations substantiate the specific gravity and porosity indications concerning vitrification.

296. Properties of refractories with reference to metallurgical practice.

W. GRUM-GRJIMALO. *Feuerfest*, **1,** 3 and 19 (1925); *Ceram. Abs.*, **4,** 278 (1925).—Discusses the corrosion of refractory linings in metal furnaces and the methods of increasing resistance. (1) To prevent further shrinkage under operating conditions material must be fired high enough to insure stable volume. (2) Permanent expansion

occurs only in poorly fired silica brick where the change to tridymite involves a volume growth up to 3.3%. (3) Refractory linings which soften under existing temperature conditions and melt together on the inner surface to form a solid wall offer good resistance as long as the temperature remains constant. (4) Accuracy of shape and freedom from cracks depend mainly on preparation of body and handling before firing. (5) The action of metal slag is influenced not so much by the composition of the brick as by the physical structure and tridymite crystals unaffected by molten iron. (6) Heat conductivity and resistance to temperature changes depend upon the homogeneity of the mass and thorough firing rather than the use of coarse-grained materials.

297. Do water-cooled furnace walls increase boiler efficiency?

J. HARVEY. *Power*, **61**, 542 (1925); *Ceram. Abs.*, **4**, 194 (1925).—The impression has been gained that the use of water-cooled walls increases the amount of heat absorbed by the boiler. Harvey is of the opinion that in properly constructed furnace walls heat is radiated inside the furnace and absorbed by the boiler-heating surface. He is doubtful if additional water-heating surface in the combustion chamber necessarily improves the heat-absorbing capacity of the boiler as a whole.

298. Optical method of determining the fusion points of refractories.

ENRIQUE HAUSER. *Rev. Mat. Constr. Trav. Pub.*, **190**, 151–61B (1925); *Ceram. Abs.*, **4**, 277 (1925).—By the use of a Féry optical pyrometer, the fusion point of numerous refractory materials was determined. The pyrometer was sighted on the end of a molded stick of the material through an opening in a wall to minimize the extraneous light. The heating was accomplished by means of an oxyhydrogen flame. Seger cones heated at the base melted at temperatures to within 10° to 20°C of their rating.

299. A laboratory load furnace.

P. D. HELSER. *Jour. Amer. Ceram. Soc.*, **8**, 822–25 (1925).—This paper illustrates the advantages of the laboratory load furnace. The points emphasized are: (1) direct application of load to specimen; (2) perfect alignment of specimen beneath the load; (3) control of temperature; (4) control of specimen throughout the atmosphere; and (5) measurement of volume changes of the specimen throughout the test.

300. Selection of fire brick by comparative tests with a detailed description of the method used to measure the temporary expansion or contraction of fire brick at various temperatures.

F. A. KOHLMEYER. *Jour. Amer. Ceram. Soc.*, **8**, 313–18 (1925); *C. A.*, **19**, 1934 (1925).—In most tests standard methods were followed. Expansion or contraction during heating was determined by sighting a transit through tubes directed toward markers on the test brick in the furnace.

301. Refractory materials for coking chambers and gas plants.

L. LITINSKY. *Feuerfest*, **1**, 65 (1925); *Ceram. Abs.*, **4**, 344 (1925).—Between the two extremes of silica (acid) and clay (basic) brick lies the group of intermediate brick containing both quartz and fireclay grog. The expansion of the silica is neutralized by the shrinkage of the grog at higher temperature resulting in a brick of stable volume. A general description of the origin and characteristics of the various raw materials used follows.

302. On the relation of softening points of the raw materials used in refractory industry.

HANS NAVRATIEL. *Tonind. Ztg.*, **49**, 517 (1925); *Ceram. Abs.*, **4**, 251 (1925).—In testing a refractory under load a curve was found which at first mounted, becoming even flatter, then bent down and fell, at first slowly, then more or less rapidly.

A softening interval was thus measured; it was from there the curve began to flatten to the horizontal. The temperature of this point is the deformation temperature. The end-point was when the cylinder had been compressed 4%. This point has less significance.

303. A general theory of spalling.

F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **8**, 29–39 (1925); *C. A.*, **19**, 1038 (1925).—It is shown that the spalling tendency is proportional to the coefficient of expansion divided by the square root of the diffusivity and the maximum sheering strain. $S = \frac{\Delta}{h\phi}$. This applies rigidly only to a homogeneous material, free from external stresses. It follows that a good spall-resisting brick should have (1) a high diffusivity; (2) a low coefficient of expansion; (3) a high flexibility in shear. In carrying the work further it would be valuable to determine: (1) the temperature distribution in a cooling brick by means of thermocouplers, esults being checked with the theory, (2) the value of h, ϕ, and Δ at all temperatures to see where $\frac{\Delta}{h\phi}$ is a maximum, (3) the effect of SiO_2 and Al_2O_3 content on the coefficient of expansion, also the effect of various firing temperatures and structures, (4) the effect of firing and structure on the flexibility.

304. The thermal expansion of refractories.

F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **8**, 799–815 (1925).—The thermal expansion or contraction of a number of typical refractories has been measured up to 1700°C in a neutral or slightly oxidizing atmosphere. In nearly every case the expansion curve has been carried to a higher temperature than given by previous data. In a few cases the expansion curve has been obtained for materials that have not been studied in this way before. It is believed that the expansion curve of a brick, if carried to the softening point, gives valuable information as to the performance of that brick in service.

305. An electric furnace for softening point determinations (in refractories).

W. L. PENDERGAST. *Jour. Amer. Ceram. Soc.*, **8**, 319–25 (1925); *C. A.*, **19**, 1933 (1925).—A graphite resistance furnace with test chamber $2\frac{1}{4}$ inches diameter is described in detail.

306. The relation of structure and composition to thermal efficiency of refractories when used in regenerators.

S. M. PHELPS. *Jour. Amer. Ceram. Soc.*, **8**, 648–54 (1925); *C. A.*, **19**, 3575 (1925). —Lowering the porosity of a checker brick increases thermal efficiency by reason of greater heat capacity which is a function of weight and specific heat. Glazing a clay brick does not materially impair its efficiency, because the greater part of the heat leaves the surface of the brick by convection and this is affected only by the surface area, which is not changed by glazing. SiC is of little value for checkers because of its low thermal capacity.

307. Refractories for use in regenerators. Relation of structure and composition to thermal efficiency of refractories.

STUART M. PHELPS. *Fuels and Fur.*, **3**, 507–8 (1925); *Ceram. Abs.*, **4**, 195 (1925) *C. A.*, **19**, 2116 (1925).—Report of investigation to determine effect of porosities on rate of heat flow in clay refractories when used as checker work in regenerators, in addition to data on other types. Conclusion that the most suitable clay refractory for this purpose is a dense brick, especially if it is subjected to slagging action.

308. Microscopic relations of sulphite and silica in blast furnace and converter linings.

T. C. PHEMISTER. *Jour. Geol.*, **33**, 275–85 (1925); *Ceram. Abs.*, **4**, 280 (1925).

309. Corrosion of fire brick, silica brick, and magnesite brick by blast-furnace and open-hearth slags.

J. PRELLER AND V. KORBER. *Chem. Listy*, **19**, 6–15 (1925); *C. A.*, **19**, 2869 (1925)—Basic open hearth slags exert a very corrosive action on SiO_2 bricks. This may be reduced by decreasing the amount of FeO in the slag and increasing CaO content so as to reduce its mobility and also by ensuring the maximum conversion of quartz to tridymite and the highest density possible in the bricks used in the lining. Care should be taken to avoid conditions favorable to the conversion of the quartz or tridymite into cristobalite.

310. Corrosion of fire brick, silica brick, and magnesite brick, by furnace slags.

J. PRELLER AND V. KORBER. *Chem. Listy*, **19**, 48–51 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 326 (1925); *Ceram. Abs.*, **4**, 221 (1925); *C. A.*, **19**, 3357 (1925).—Basic slags corrode magnesite brick less than fire brick or silica brick, and the action is less, the smaller the periclase crystals, the denser the brick, the smaller the SiO_2 content, and the slower it is cooled. Silica favors formation of olivine and this reduces the softening point to the brick.

311. Experience with siliceous material at Leopoldau Gas Works, Vienna.

PRETSCH. *Gas World*, **82**, 70 (1925); *Ceram. Abs.*, **4**, 107 (1925).—Original setting of clay gave trouble due to fusion because of high temperature operation. In 1914 a change to silica was made in one unit and later the entire works was changed. Lowering of coking time 12% and 100°C cooler flues. Shut down part of set in summer with slight cracking of walls, but expansion gradually became constant. Three thousand days was the life of the silica when in use.

312. Refractories Institute defined.

J. D. RAMSAY. *Brick and Clay Rec.*, **66**, 661 (1925); *Ceram. Abs.*, **4**, 343 (1925).—Central bureau to develop real research work and forum for consumer and producer problem discussion are its main objects.

313. Alumina-silica minerals in fire brick.

W. J. REES. *Trans. Ceram. Soc.* (Eng.), **24**, 23 (1925); *Ceram. Abs.*, **4**, 310 (1925).—Extractions were made on pieces of 5 fire brick of various alumina-silica ratios (49 : 30 : : 67 : 27) both as received and after reheating to cones 18 and 26. HF was used for 12 hours at constant temperature. The amount of insoluble residue increased with increased temperature and analyzed close to the composition of mullite.

314. Some fallacies to be avoided in standardization of load-bearing capacity of refractories at high temperatures.

T. F. RHEAD AND R. E. JEFFERSON. *Gas Jour.*, **171**, 46–49 (1925); *Ceram. Abs.*, **4**, 310 (1925).—Various load-testing methods were reviewed and new means described. The fallacy of heating at 1350°C for two hours is shown by two bricks being heated beyond this at the rate of 50°C per five minutes. The one failing before at 1350° did not fail until 1450° while the second started to shrink at 1350°C. The subsidence is compared to that of a viscous material. The results of the work showed that a consideration should be made of (1) the temperature at which subsidence becomes apparent, (2) the temperature at which marked acceleration of subsidence occurs, (3) the subsidence of range, (4) the effect of load on the temperature extent of subsidence range, (5) the appearance of the piece after testing.

315. Water-cooled furnaces.

H. D. SAVAGE. *Mech.-Eng.*, **47**, 197 (1925); *Ceram. Abs.*, **4**, 134 (1925).—Furnace linings have not been keeping pace with the studies being made in other features of

power plant development. Higher settings, higher ratings, and higher efficiencies now being made have placed a duty upon boiler furnaces that cannot be met satisfactorily by refractories available or of common or standard use. This has led to (1) hollow-wall refractories furnace, (2) steam-cooled walls, (3) water-cooled walls. The completely water-cooled furnace or a combination of water-cooled and refractories furnace would seem to present the greatest possibilities for future interest. The author deals with a number of water-cooled furnaces of the finned type, or as it is now called, fin furnace.

316. Preliminary findings in refractory investigations. I.

R. A. SHERMAN, P. D. HELSER, H. W. BROOKS, AND G. A. BOLE. *Power*, **62**, 234–37 (1925); *Ceram. Abs.*, **4**, 344 (1925); *C. A.*, **19**, 3153 (1925).—The U. S. Bur. Mines and 18 companies investigated boiler-furnace refractories. Among the causes of failure studied are fusion, distortion under load, spalling, slag action, failure of support, thermal expansion and contraction, permanent volume changes, and furnace wall construction.

317. Ibid. II.

P. D. HELSER AND G. A. BOLE. *Power*, **63**, 277 (1925); *Ceram. Abs.*, **4**, 344 (1925).—This part deals with the raw materials entering into and the method of manufacture of boiler furnace refractories materials; some of their physical and chemical properties are given. Among the special refractory materials studied are diaspore, bauxite, kaolin, and silicon carbide. The method of manufacture and influence of properties on the wares forms an interesting part of this investigation.

318. Present state of knowledge of the resistance of smelting industry refractories toward changes in temperature.

W. STEGER. *Ceramist*, **6**, 374–84 (1925); *Ceram. Abs.*, **4**, 345 (1925).—The sensitiveness of a body to temperature changes depends on not only the chemical composition but also the shape and physical structure of the body. S. discusses rapid methods of measuring a body's resistance to temperature changes and also the formula of Winkleman and Schott for calculating it from measurable physical constants. The resistance to spalling of a fire brick depends on (1) structure, (2) porosity, (3) chemical composition, (4) firing temperature. The resistance of silica brick to temperature change is dependent upon the mineralogical character of the silica. S. agrees witn Mellor that the sensitiveness of magnesite brick is due to (1) incomplete preliminary firing of the magnesia, (2) the large coefficient of expansion of magnesia. S. questions Mellor's demonstration of the existence of 2 forms of magnesia as Mellor's results can be attributed to the fact that the specific gravity of amorphous magnesia depends on the firing temperature of the magnesite used in its production as shown by A. Ditte. A further cause of the sensitivity of magnesite brick is found in its high degree of sintering.

319. Resistance of refractory materials to temperature changes.

W. STEGER. *Stahl u. Eisen*, **45**, 249–59 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 284 (1925); *Ceram. Abs.*, **4**, 195 (1925).—Quenching experiments on brick give the following relative values for sensibility to change of temperature; Carborundum 2, bauxite 13, zirconia 16, fire clay 3–30, chromite 42, silica 75, magnesite 100. The coefficient of expansion was measured in 4 temperature ranges, 15–300°, 300–500°, 500–600°, and 600–750°. The sensibility of silica brick at low temperature is caused by the α–β cristobalite transformation at 230°. If quartz is present, as in badly fired brick, the greatest expansion is in the third temperature range. Carborundum shows uniform expansion in all the temperature ranges.

320. Staining process for testing refractory materials.

E. STEINHOFF AND F. HARTMANN. *Stahl u. Eisen*, **45**, 337–43 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 317–18 (1925); *Ceram. Abs.*, **4**, 221 (1925).—Staining after etching is

applied to refractories. It supplies data on: the temperature of fired clays and clay grog brick; the occurrence, distribution, and degree of modification of quartz; localized CaO and MgO fusion; presence and position of thin layers of kaolin in quartzite; extent of modification in silica brick; and behavior of silicate fusions. The etching solution consists of equal parts of concentrated HCl and saturated $AlCl_3$. The gelatinized ingredients are stained with methylene blue.

321. The influence of oxidizing and reducing atmospheres on refractory materials.

A. E. VICKERS AND L. S. THEOBALD. *Gas Jour.*, **171**, 27–30 (1925); *Trans. Ceram. Soc.* (Eng.), **24**, 87–104 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 716–17 (1925); *Ceram. Abs.*, **4**, 309 (1925).—Fusions were made in an electric furnace using various atmospheres and additions of Fe_2O_3 were made to cone mixtures. Nitrogen was used as the basis of the report for a standard gas. Air acted on the fusion midway between nitrogen and oxygen, oxygen giving slightly higher values. SO_2 and CO_2 act slightly as reducing gases lowering the fusion points as the Fe_2O_3 increases. H_2 acts strongly as a reducing gas lowering the fusion 250°C in highest Fe_2O_3 content or 2.5 % in Thivier's earth.

322. Refractory materials for coking chambers and gas plants.

E. WEBER. *Feuerfest*, **1** [5], 27 (1925); *Ceram. Abs.*, **4**, 288 (1925).—The older and newer methods of testing fire clay are discussed. Chemical analysis alone is not sufficient but determination of melting point, softening point under load, and coefficient of expansion are important.

323. Radiation in the pulverized fuel furnace.

W. J. WOHLENBERG AND D. G. MORROW. *Mech. Eng.*, **47**, 627 (1925); *Ceram. Abs.*, **4**, 344 (1925).—It is shown that the radiating power through the flame surface depends primarily on the size of the particle and that, based on the flame surface area, its magnitude is low. The heat absorption intensity at the cold surface may be considerably higher than the relative radiance of the flame. This factor depends on both the amount and the disposition of the refractory furnace lining. Curves are given supplementing the analytical process by which the method outlined may be applied.

FIRE CLAY

324. Does the size of particles have any influence in determining the resistance of fire clays to heat and to fluxes?

H. O. HOFFMAN AND B. STOUGHTON. *Trans. Amer. Inst. Min. Eng.*, **28**, 440–44 (1898).

325. Note on tensile strength of raw clays.

H. RIES. *Trans. Amer. Ceram. Soc.*, **6**, 79–82 (1904); *Jour. Soc. Chem. Ind.*, **24**, 134 (1905).—Too much fire clay weakens. Too much grog weakens. We wish varying sizes. Perhaps mixtures of coarse and fine clays are best. It is incorrect to use tensile strength as a measure of plasticity.

326. Note on high Al_2O_3–SiO_2 clay.

A. F. GREAVES-WALKER. *Trans. Amer. Ceram. Soc.*, **8**, 297–300 (1906).—Olive Hill clay analysis.

327. Action of gases on fireclay brick.

T. HOLGATE. *Tonwar. Ind.*, **10**, 148 (1906); *Trans. Ceram. Soc.* (Eng.), **5–6**, 23A (1905–7).

328. The destruction of fire brick by blast furnace gases.

E. CRAMER. *Tonind. Ztg.*, **31**, 1383 (1907); *Trans. Ceram. Soc.* (Eng.), **7-8**, 29A (1907–9).—The greatest action of the blast-furnace gases takes place 40–50 ft. from the top of the furnace at the temperatures 300 to 800°. At 400–500° the action of the gas CO is much more rapid than at the lower or higher temperatures. The reaction is $2CO \rightarrow CO_2 + C$. The carbon is deposited in the brick, which causes a soft and weakened structure.

329. Flint fireclay deposits in N. E. Kentucky.

A. F. GREAVES-WALKER. *Trans. Amer. Ceram. Soc.*, **9**, 461–72 (1907).—Analysis, maps, and tests; good article.

330. The testing of fire clays.

F. J. BYWATER. *Brit. Clayworker*, **17**, 88–89, 96–104 (1908); *C. A.*, **3**, 363 (1909).—Describes general properties of fire clays especially for gas works use. Two testing furnaces are illustrated. Dense wares are to be avoided.

331. The application of the grog in firebrick manufacture.

G. RIGG. *Met. Chem. Eng.*, **8**, 523–25 (1910); *C. A.*, **4**, 3288 (1910).—Discusses the failure of brick on account of the grog and discusses the sizing of the grog and results of tests.

332. Defects of refractory brick and their causes.

G. RIGG. *Met. Chem. Eng.*, **8**, 237–38 (1910); *C. A.*, **4**, 1799 (1910).—Description of the working properties of fire brick.

333. Standard specifications for retort and firebrick material.

ANON. *Jour. Gas Lighting*, pp. 843–45, June 20, 1911.—Report of Refractory Materials Committee of the British Gas Institute. This specification covers fireclay products carrying up to 80% silica. Two grades are included, No. 1 being material which shows no sign of fusion at a temperature not less than 1670°C, and No. 2 being material which shows no sign of fusion at temperature not less than 1580°C. The No. 1 grade must show not over $\frac{3}{4}$% expansion or contraction when heated for two hours at 1350°C, and No. 2 must show not over 1%. In the case of ordinary 9-inch straights there must not be more than $1\frac{1}{2}$% variation in length, plus or minus, and not over $2\frac{1}{2}$% in width or thickness. In all cases the bricks must work out their own bond, with no more than $\frac{1}{8}$-inch joint. In the case of special shapes, there must not be more than 2% variation from any specified dimension. The material must stand a crushing strength of not less than 1800 lbs. per sq. in. when applied in a prescribed manner. Nine clauses are given, of which four important ones are here abstracted. The specification is the work of a joint committee of the Retort and Firebrick Section of the Society of British Gas Industries and the Refractory Materials Committee of the British Gas Institute. The specification has been adopted as standard by the Institute.

334. The destruction of fire brick in coke ovens and the reasons therefore.

B. KOSMAN. *Stahl u. Eisen*, **31**, 730–31; *C. A.*, **3**, 3334 (1911).—K. ascribes the destruction to the entrance of C into the red hot lining, forming Si carbides, which are deposited in the pores as graphite.

335. Cause of permanent expansion in fire brick.

J. M. OGAN. *Trans. Amer. Ceram. Soc.*, **13**, 602–11 (1911); *Chem. Trade Jour. and Chem. Eng.*, March 9, 1912.—It has been noticed that the volume of fire brick permanently increases after heating. This expansion is due to the formation of an impervious globule structure in the glassy matrix formed by fusion. The failure of fire

brick at high temperatures has also been investigated. At a load of 50 lbs. per sq. in. no fire brick can withstand a temperature of 1350°C, if the alkali equivalent be more than 0.225. Silica present in excess of the formula $Al_2O_3.2SiO_2$ adds to the fluxing power of the alkali. Experiments showed that most fire brick failed at about 125 lb. per sq. in. and that there is no relation between the crushing strength of a brick at ordinary temperature and at 1300°C.

336. Firebrick furnace arches.

A. E. DIXON. *Power*, **35** [8], 246(1912).—Trouble with arches when exposed to intense heat is usually due more to the fact that few bricklayers are posted on the laying of fire brick, than to the fire brick itself. The inexperienced bricklayer seems to have the idea that his trowel is necessary on firebrick work, when in reality all that he needs is his "scutch" or hammer. Fireclay mortar must be very thinly mixed. Occasionally an attempt to describe it in the specifications reads: "Mixed to the consistency of a thin gruel." Within limits, the thinner it is, the better. A thin batter that will flow readily is a better description. Pails are used to carry this mortar and the bricklayers should be supplied with tubs. With the above criticism, D. proceeds to discuss the general subjects under the following headings: fire clay, boiler furnaces, firebrick arches, rise of arch upon thrust, and method to determine number of brick.

337. Studies of flint clays and their associates.

SIDNEY L. GALPIN. *Trans. Amer. Ceram. Soc.*, **14**, 301–46(1912).—(1) Flint clays formed by setting and recrystallization of colloids purified by CO_2 in water. (2) Semi-flint results from changing of flint clay under P and T into coarser crystals. (3) Plastic clays associated with flint clays have weathered more. (4) Muscovite may change to kaolin without change in structure. (5) Microstructure explains chemical and physical behavior.

338. Firebrick failures.

J. M. OGAN. *Jour. Gas Lighting*, **118**, 16(1912); *Trans. Ceram. Soc.* (Eng.), **12**, 5A(1913).—At a load of 50 lbs. per sq. in. no fire brick can withstand a temperature of 1300° if the alkali equivalent is more than 0.225. Silica present in excess of the formula $Al_2O_3.2SiO_2$ adds to the fluxing power of the alkali. There is no relation between the cold and hot crushing strength.

339. Settling and filtering of fire clays.

G. E. THOMAS. *Trans. Amer. Ceram. Soc.*, **14**, 399–406(1912).—Effect of weathering on St. Louis fire clay.

340. Fireclay deposits in Canada.

H. RIES. *Trans. Amer. Inst. Min. Eng.*, **45**, 123–36(1913).—Tests and possibilities offered.

341. Deterioration of fire brick.

G. RIGG. *Jour. Ind. Eng. Chem.*, **5**, 549(1913); *Trans. Ceram. Soc.* (Eng.) **17**, 115A(1918); *C. A.*, **7**, 3005(1913).—A discussion of circumstances which promote deterioration. The more compact and close-grained the bricks, the greater the resistance to the action to corrosive slags and gases. Spalling of the close-grained bricks results from using unsuitable clay, or from poor workmanship or both. Close-grained fire brick can be prepared so as to contain a considerable proportion of coarse material if the grog be carefully sized so that the smaller particles may fill the spaces between the larger pieces. See also *Brick Pottery Trades Jour.*, **21** [8], 319–23(1913); *Trans. Ceram. Soc.* (Eng.), **13**, 20A(1914).

342. Refractory materials in gas works.

J. W. MELLOR. *Jour. Gas Lighting*, **125**, 647–50; *C. A.*, **8**, 1866 (1914).—Account of many problems connected with the refractory material industry. Subjects dealt with: softening temperature of clay, refractory tests, porosity of gas retorts, composition of a retort, the texture of gas retorts, and the action of dust on gas retorts.

343. The actions of flue dust on fire bricks.

J. W. MELLOR. *Trans. Ceram. Soc.* (Eng.), **13**, 12–14 (1914); *ibid*, **14**, 25A (1915); *C. A.*, **8**, 3847 (1914); *Jour. Soc. Chem. Ind.*, **33**, 259.—The analyses of the fire brick, the fuel ash, and the resulting slag are given. The analysis of the slag is 95–99% fuel ash, and a small amount of refractory material. By mixing fire clay and fuel ash in varying proportions it was found that the fire clays are very sensitive to the presence of fuel ash. However, in the use of the fire clay, the fuel ash forms a sort of a glazed coating which helps to protect the fire brick.

344. Refractories of the Rocky Mt. region and some of their products.

J. C. BAILAR. *Met. Chem. Eng.*, **13**, 257–58 (1915).—Analysis of fire clays:

TABLE I

ANALYSES OF COLORADO CLAYS AND SHALES

	1	2	3	4
SiO_2	50.35	45.99	46.61	56.41
Al_2O_3	34.44	36.94	37.20	26.37
FeO	.75	.75	.15	0
MgO	trace	.36	.25	.20
CaO	.00	.23	.44	.29
Na_2O	.10	.45	1.23	1.55
K_2O	.48	.48		
Ignition	13.88	14.13	13.65	14.66

Also make acid-resisting and alkali-resisting porcelain.

345. Deterioration of fireclay goods in coke ovens and gas retorts. I.

THOMAS HOLGATE. *Gas World*, **63**, 32–33 (1915); *C. A.*, **9**, 2584 (1915).—The effect of carbon deposits, of NaCl in the coal and also in the water, are discussed. **II**. *Ibid*, 50–53.—A study of the change of the constituents of fire clay after use.

346. Deterioration of fire clay.

T. HOLGATE. *Brit. Clayworker*, **24**, 122 (1915); *C. A.*, **10**, 103 (1916).—There is a clashing of opinions as to whether the salt vapors present in coke ovens cause damage by attack of SiO_2 or Al_2O_3 in the brick. H. suggests that damage is caused by the formation of $AlCl_3$ which is a powerful catalyst to the action of carbon-bearing gases. A brick rich in Al_2O_3 suffered more from loss of silica than loss of Al_2O_3. Alkalis which penetrate the brick produce a fusible silicate. Iron promotes a greater fusibility with silica brick than it does with aluminous brick.

347. Fireclay goods and their use in gas works.

THOMAS HOLGATE. *Jour. Gas Lighting and Water Supply*, **128** [2687]; 292, 363–64, 480–81, 536–37, 599–600, 661; *C. A.*, **9**, 1539 (1915).—Results of tests by J. W. Mellor, of putting pressure on the brick while hot. A number of tests were made by keeping the temperature at 1350°C, and noting the effect of successive pressure. With 50 lbs. per sq. in., the bricks being placed on end, no firebrick body could be found to withstand 1350°C, if the alkali equivalent be more than 0.225. Indeed, when silica was

present in excess of the ratio "alumina (Al_2O_3): 2 silica (SiO_2)"—that existing in kaolin—the alkali content was more effective in fluxing power. Thus, with 4.4 SiO_2 per molecule of alumina, failure under the load was brought about by 0.17 equivalent of RO. Experiments at other pressures showed that most fire bricks fail under 125 lbs. per sq. in. when heated to 1350°C. The highest pressure in the experiments of the 1914 report of the Refractory Materials Committee is 112 lbs. per sq. in. and by graphical methods this may be extended to see what is likely to occur at the 125 lbs. found to be the maxium for American clays. The following table gives the results found:

SHOWING THE APPROXIMATE MELTING POINT OF CLAYS UNDER A PRESSURE OF 125 LBS. PER SQ. IN.

No. of clay in Committee's report	Melting points found by expt.			Computed for 125 lbs. pressure from 3 preceding columns ° C
	Normal ° C	84 lbs. ° C	112 lbs. ° C	
17	1770	1520	1410	1366
9	1750	1580	1580	1580
16	1730	1460	1410	1387
4	1710	1500	1435	1405
3	1690	1460	1380	1343
10	1690	1500	1460	1441
5	1670	1460	1380	1343
11	1670	1460	1380	1343

348. Characteristics of fire brick for boiler furnaces.

E. H. TENNEY. *Elec. World*, **66**, 1086–87 (1915); *Sci. Abs.*, **19B**, 124 (1915).—Deals with the effect of furnace conditions on fire brick; with the placing of furnace settings; and the construction of ignition arches to secure longest life.

349. White firing clays of Southern Appalachian States.

J. H. WATKINS. *Trans. Amer. Inst. Min. Eng.*, **51**, 481–501 (1915).

350. Methods of calcining clay for grog.

C. B. HARROP. *Trans. Amer. Ceram. Soc.*, **18**, 165 (1916).—Descriptions of suitable kilns for calcining. Continuously operated kiln will come into more use for calcining purposes. Purpose of calcining: (1) To increase the refractoriness of the ware by forming a skeleton which may remain erect after bond clay begins to soften. (2) To produce a less dense body and thereby reduce the chance of damage due to temperature changes.

351. Pennsylvania fire clay.

L. C. MORGANROTH. *Trans. Amer. Inst. Min. Eng.*, **54**, 477–84 (1916).—Geological formations.

352. Refractory materials for coke ovens, etc.

M. BARRETT AND LEEDS FIRECLAY CO. Brit. 103,953, Aug. 18, 1916; *C. A.*, **11**, 1895 (1917).—Composition of body mixture given. Material in contact with coal is polished, fired, and while still incandescent. treated with alkaline vapors.

353. Properties of some American bond clays.

A. V. BLEININGER AND G. A. LOOMIS. *Trans. Amer. Ceram. Soc.*, **19**, 601 (1917).—Make drying shrinkage, water of plasticity, apparent specific gravity in dry state; rate of slaking; modulus of rupture; porosity and volume change; softening point determinations on 28 clays from various localities. Complete data given.

354. Properties of plastic European fire clays.

A. V. BLEININGER AND H. G. SCHURECHT. Bur. Stand., *Tech. Paper.*, No. 79.

355. Refractory materials.

J. W. COBB. *Trans. Faraday Soc.*, **12,** 150(1917); *Trans. Ceram. Soc.* (Eng.), **16,** 89(1917).—For a typical siliceous fire brick consisting essentially of a clay binder and silica grains the most general conditions of use would be met by making the binder as fine and close grained as possible, and the grains fairly large. The stiffening effect of a silica addition is lost if the material be very fine. This results from chemical and solvent action on the large exposed surface of fine silica and not from any intrinsic lack of stiffening power inherent in fine material, as is clear from experiments in which chemical action was excluded.

356. The effect of the size of grog in fireclay bodies.

F. A. KIRKPATRICK. *Trans. Amer. Ceram. Soc.*, **19,** 268–99(1917); *C. A.*, **12,** 611(1918).—Modulus of rupture increased with the surface factor of the grog. The rate of strength increase, increased with the firing temperature. Large size grog was found best for quenching tests from 600–1000°.

357. Refractory materials.

A. A. KNOX. *Trans. Faraday Soc.*, **12,** 144(1917); *Trans. Ceram. Soc.* (Eng.), **16,** 88A(1917).—Before the war gas retorts made in Scotland had a life of 2400 days and an average never less than 1200 days. The ultimate analysis is given for this refractory.

358. Some properties of fire clays.

J. W. MELLOR. *Jour. West Scot. Iron and Steel Inst.*, **24,** 104(1917); *Trans. Ceram. Soc.* (Eng.), **16,** 46A(1917).—The importance of the heating curve of clays was discussed, as well as the effects of heat at different stages of the firing process. It was particularly emphasized that after heating to about 600° the changed material is more active chemically, especially as regards absorption and retention of sulphurous fumes.

359. The relation between the fusion point and the composition of refractory clays.

R. J. MONTGOMERY AND C. E. FULTON. *Trans. Amer. Ceram. Soc.*, **19,** 303–11 (1917); *C. A.*, **12,** 608(1918).—Gives analyses and softening points of 57 refractory clays. Mixtures of clays and SiO_2 included. Results interpreted according to SiO_2–Al_2O_3 eutectic diagram.

360. Distribution and geological position of valuable fire clays and ganisters of the south of Scotland.

L. HINXMAN AND M. MACGREGOR. *Trans. Ceram. Soc.* (Eng.), **17,** 35–56(1918).

361. Kaolin in Quebec.

J. KERLE. *Jour. Amer. Ceram. Soc.*, **1,** 824(1918).—Unusual geology in district.

362. The porosity and volume changes of clay fire brick at furnace temperatures.

G. A. LOOMIS. *Jour. Amer. Ceram. Soc.*, **1,** 384–404(1918); *C. A.*, **13,** 174(1918).—Most bricks showing a porosity decrease of not over 5% and volume change of not over 3% when fired to 1400° will pass the load test while those with greater changes will fail. No definite relation between melting point and load carrying capacity.

363. Notes on fire brick from crown of an electric steel melting furnace.

W. J. REES. *Trans. Ceram. Soc.* (Eng.), **17,** 248–49(1918); *C. A.*, **13,** 644(1919).—Chemical analysis of fire brick after 145 charges; softening point was cone 37. Fluxed end of brick showed abundant sillimanite. Brick made from almost non-plastic bauxite clay.

364. The occurrence of high grade American clays and the possibility of their future development.

H. RIES. *Jour. Amer. Ceram. Soc.*, **1**, 446 (1918).—Outlook for greater development of domestic clays is good. The reserve in many areas in the U. S. is sufficient for some time to come. This country can supply satisfactory refractory clays of high bonding strength without the use of important materials. If single clays are not suitable the desired properties may be obtained by judicious blending of two or more clays.

365. A study of the microstructure of some clays in relation to their period of firing.

H. RIES AND Y. OINOUYE. *Trans. Amer. Inst. Min. Eng.*, **58**, 184–97 (1918).

366. The properties of some Ohio and Pennsylvania stoneware clays.

H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **1**, 267–86 (1918).—The following samples were tested: (*a*) Tronesta Clay, Ellis, O.; (*b*) Lower Kittanning Clay, Roseville, O.; (*c*) Lower Mercer Clay, White Cottage, O.; (*d*) clay from Mogadore, O.; (*e*) Lower Kittanning Clay, Toronto, O.; (*f*) same from New Brighton, Pa.; (*g*) same as (*f*) but another bed; (*h*) Tronesta Clay, Crooksville, O.; (*i*) same as (*e*) but from Firebrick, O.; (*j*) same, Nelsonville, O.; (*k*) same, Scioto Furnace, O. Complete data are recorded showing per cent residue on 150-mesh, per cent porosity dry, density dry, modulus of rupture, dried 110°, per cent warpage at cones 1, 2, and 4, per cent loss of strength due to quenching, and softening point in cones.

367. Clays of Florida.

E. H. SELLARDS. *Jour. Amer. Ceram. Soc.*, **1**, 313–21 (1918).—Plastic kaolins, etc.

368. Fire clays in northern Idaho.

E. K. SOPER. *Jour. Amer. Ceram. Soc.*, **1**, 94–98 (1918).—Soper describes location, geology, extent, and quality of the fire clays of northern Idaho. Two plants were operating in 1913.

369. Nova Scotia fire clays make good refractories.

ANON. *Brick and Clay Rec.*, **55**, 1037–38 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 80 (1920).—The fire clay described is on the island of Cape Breton, Nova Scotia. Two clays, one from Truro, N. S., and another from Sydney, N. S., are mixed together and make good refractories for coke-oven walls, gas producer linings, and so forth. The chemical analyses are as follows:

	1	2		1	2
Organic matter	7.76	4.46	Ferric oxide	1.30	2.23
Silica	71.48	79.56	Lime	.55	Trace
Alumina	17.91	13.87	Magnesia	Trace	Trace

1. From Truro, N. S., and has a fusion point of 1670°C.
2. From Sydney, N. S., and has a fusion point of 1750°C.

370. Test for softening point of fireclay brick.

ANON. *Proc. A.S.T.M.*, **19** [1], 594–96 (1919); *Power*, p. 636, Oct. 19 (1920).—A full description of the A.S.T.M. standard method for determining the softening point of fireclay brick.

371. White clay possibilities of Pennsylvania.

R. R. HICE. *Jour. Amer. Ceram. Soc.*, **2**, 685–94 (1919).—The deposits worked in S. E. Pa. occur within the sedimentary rocks at 4 different horizons. The relations are not yet clearly worked out. At some points the clays seem to have been derived from the decomposition of shales and at other places from sandstone or limestone. Their geology is discussed. These clays are mostly sold in the crude form. The clays are used in steel plants for molding purposes, and some as paper clay, but little, if any, are used for pottery.

372. Blast furnace refractories.

R. M. Howe. *Bull. Amer. Inst. Min. Met. Eng.*, 1791–1802 (1919); *C. A.*, **13**, 3299 (1919).—H. expects to show that grinding flint clay with the plastic clay, even up to 40% flint, greatly increases resistance to spalling. Mining and sorting, grinding, proportioning, tempering, shaping, drying, firing, and installing are discussed. Effect of water on modulus of rupture given. Some causes of failure not due to refractories are given.

373. Blast furnace refractories.

R. M. Howe. *Min. and Met.*, 3049–50 (1919); *C. A.*, **14**, 328 (1920).—Discussion on: (*a*) Variation in moisture content of pug. (*b*) Fineness in 2 pans in same operation. (*c*) Percentage of spalling loss at 1350° for bricks from different makers. (*d*) Spalling loss on checker brick from different makers. (*e*) Crushing strength at 1350° of 10 bricks from same car. (*f*) Slagging tests, penetration of molten blast-furnace slag at 1350°, three bricks of each brand.

374. Notes on fire clays of the Northern Appalachian coal basin.

Ellis Lovejoy. *Jour. Amer. Ceram. Soc.*, **2**, 374 (1919); See also G. H. Ashley discussion, *ibid.*, **2**, 790 (1919).—The chief flint fire clays of the Northern Appalachian coal basin are: (1) The Sciotoville in Kentucky. This is largely mined at Olive Hill, Ky. It is the Sharon horizon in Pennsylvania, but is known as the Sciotoville or No. 1 in Ohio. (2) The Mercer in Pennsylvania and Maryland. This is mined in Central Pa. and near Cumberland, Md. (3) The Lower Kittanning in Pennsylvania, Maryland, and Ohio where it is known as No. 5. (4) The Upper Freeport in Pennsylvania, Maryland, and Ohio (No. 7 in Ohio). A description of the occurrence, appearance, and geology of these four clays.

375. Clays in the foundry.

H. T. Stahle. *Foundry*, **47**, 310–11 (1919); *Jour. Amer. Foundry Assoc.*, **34** (1919).—General description of foundry use.

376. Transverse strength of fireclay tile.

Anon. Bur. Stand., *Tech. News Bull.*, 40 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 850 (1920).—A number of tests have just been completed on fireclay tile subjected to a temperature of 1350°C in order to determine the modulus of rupture and the deformation. The surprising fact was brought out that these tiles, in spite of their weight and bulk, cannot support any appreciable load beyond their own weight, and in the case of long spans it was found that the tiles broke without any imposed load. It is quite possible that for load-carrying refractories of this type, entirely different compositions and combinations of clay and grog must be resorted to.

377. The composition, drying and firing shrinkage, porosity, and density of British fire clays suitable for glass furnace refractory materials.

Anon. *Jour. Soc. Glass Tech.*, **4**, 162–204 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 924 (1920).—Twenty-seven clays from mines in England, Wales, and Scotland were examined and detailed information is given in tabular form.

378. Muffles.

Anon. *Tonind. Ztg.*, **44**, 168–69 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 504 (1920).—The requirements of a muffle are (1) resistance to temperature changes, (2) mechanical strength, and (3) good conductivity. About 2 parts of grog are used with 1 part of bond clay. Sawdust is often added to the body to make it light, and more resistant to sudden temperature changes.

379. Note on the influence of grog in admixture with clay.

WALTER C. HANCOCK. *Trans. Ceram. Soc.* (Eng.), **19,** 149–52 (1920).

380. Fireclay mixture for high temperatures.

R. M. HOWE. *Blast Fur. and Steel Plant,* **3,** 157–60 (1920).—Results of experiments upon the lowering of fusion point of a fire clay by additions of cement, asbestos, salt, water-glass, and SiC. To overcome the shrinkage of clay used as mortar add very fine grog.

381. Kaolin of Indiana.

W. N. LOGAN. Ind. State Dept. of Conservation, *Bull.,* **6** (1920); *Econ. Geol.,* **15,** 542 (1920); *Jour. Amer. Ceram. Soc.,* **4,** 423 (1921).—The beds occur at or near the top of the Mississippian in several counties in the S. W. part of the state. All beds have sandstone above and shale below. Only slight commercial development has taken place to date, although large quantities of high-grade white clays are present. The discussion covers the physical and chemical properties of the kaolin, geological conditions or occurrence, origin, uses, and distribution by counties. Earlier explanations of origin are disproved. Laboratory experiments and microscopical examination show that the origin is biochemical. Certain S bacteria are believed to be able to secrete kaolin. The S bacteria obtain S from pyrite in the shale. H_2SO_4 formed attacks the shale and the resulting compound reacts with quartz of the sandstone, S being replaced by SiO_2, forming kaolin.

382. Porosity and volume changes of clay fire bricks at furnace temperatures.

G. A. LOOMIS. Bur. Stands., *Tech. Paper,* No. 159 (1920); *Jour. Amer. Ceram. Soc.,* **3,** 581 (1920); *C. A.,* **14,** 3141 (1920).—Deals with the permanent changes in porosity and volume of fireclay bricks when refired to temperatures to or above those to which they were originally fired. These were measured for a series of temperatures to determine what relation, if any, might exist between these changes and the deformation of the same bricks under load at furnace temperatures. The possibility of such a relation is suggested by the fact that contraction of clay on heating and decrease in porosity are, to a certain extent, indications of the amount of softening of the mass due to the action of fluxes present, and hence indicative of decreased resistance to deformation under pressure or decreased viscosity. Softening point determinations were also made to determine what exact relation these might bear to the result of the load test. The results of tests on a large number of fireclay bricks from various parts of the United States showed that bricks which withstood a load test of 40 lbs. per sq. in. at 1350°C without marked deformation showed no marked changes in porosity or volume up to 1425°C. Bricks which did not withstand the test generally showed appreciable contraction or expansion accompanied by considerable decrease in porosity. Bricks which showed overfiring and the development of vesicular structure below 1425°C by marked expansion or increase in porosity invariably failed completely under load. In general, bricks which showed a decrease in porosity exceeding 5% or a volume change exceeding 3%, (amounting to about 1% in linear dimensions) when refired to 1400°C failed to pass the load test. No definite relation could be determined between the softening point of a brick and its ability to withstand pressure at high temperature All bricks softening below cone 28 failed completely in the load test. Some showing quite high softening points also failed, probably due to the use of an inferior bond clay in the mixture or too small an amount of bonding material.

383. Fire clays from Andenne.

O. MUHLHAUSER. *Z. angew. Chem.,* **32** [1], 14–16; *C. A.,* **14,** 1743 (1920).—In western Germany the Andenne fire clays are widely used for Zn muffles. In Belforge

fat clay has been used for over 50 years as a bond clay for Zn muffles. Physical data on these clays.

384. Refractory brick for boiler furnaces.

P. SCHNEIDER. *Tonind. Ztg.*, **44**, 57–59 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 412 (1920); *C. A.*, **14**, 1202 (1920).—Division of the refractories in 2 classes, and the requirements of the brick for the conditions they must meet. The brick for class A should have a deformation point at cones 31–33, should be fired above cone 10 and should not have more than 2% volume change after being put in the furnace. Bricks with coarse-grained grog or flint clay should be used, as they withstand temperature changes better. Bricks for class B should have a deformation of cone 26.

385. Use of plastic clay grog in preventing spalling.

R. M. HOWE AND S. M. PHELPS. *Jour. Amer. Ceram. Soc.*, **4**, 119–26 (1921); *C. A.*, **16**, 1302 (1922).—A plastic fire clay was calcined to cone 8 and the grog crushed and mixed with plastic clay in various proportions up to 40%. Resistance to spalling was increased about 5% for each 1% of grog added, the bricks containing grog being weaker and more porous, and showing less shrinkage in drying and firing.

386. Refractories under load.

H. J. KNOLLMAN. *Jour. Amer. Ceram. Soc.*, **4**, 759–70 (1921); *C. A.*, **16**, 323 (1922). —The discussion concerns refractories used in firing grinding wheels. The selection and mixing of the clays and the making of the slabs, etc., are probably more important than actual properties of the clays. Hard firing to about cone 14 is essential to good results. Refractories superior to fire clay are much needed.

387. Illinois fire clays.

C. W. PARMELEE AND C. R. SCHROYER. *Ill. State Geol. Surv. Bull.*, **38**, 149 (1921); *Ceram. Abs.*, **1**, 316 (1922).—A proposed new classification of clays according to use includes: I, clays firing white or cream colored, not calcareous; IA, open firing, porous at cone 15; IB, dense firing, non-porous or nearly so at cones 10–15; IC, dense firing, non-porous or nearly so at cones 5–10; II, buff firing clays; IIA, refractory; IIB, non-refractory; III, clays firing red, brown, or other dark color; IIIA, open firing, not attaining low porosity until near or at the fusing point; IIIB, dense firing with a more or less extended vitrification range; IV, clays firing dirty white, cream, or yellowish white. Further subdivisions are given and the typical uses for the different classes are given. The various types of clays are described and methods of conducting the physical tests are detailed. The geology of Illinois clays is reviewed and many deposits are described. Judged by their physical properties the samples are classified as follows: refractory clays showing a porosity of 5% or less at cone 9 or under, 20; refractory clays showing porosity of over 5% below cone 9, 30; stoneware clays, 48; architectural terra cotta clays, 53; sewer pipe clays, 9; face brick clays, 45; common brick, tile, etc., clays, 10; sanitary ware clays, 48. The same clay may appear in more than one of the above classes.

388. A study of the heating and cooling curves of Japanese kaolinite.

S. SATOH. *Jour. Amer. Ceram. Soc.*, **4**, 182–94 (1921).—Microscopic examination showed changes at about 600° and at 900–1000° where it became isotropic. It became granular at 1250–1300° and developed sillimanite near 1400°. Differential heating and cooling curves were plotted with quartz sand as comparison. These curves showed an endothermic reaction from 450–700°, an exothermic near 950°, an exothermic at 1200–1300°, and other less distinct reactions. The maximum rate of loss of weight on ignition occurred at about 450°. Similar curves were plotted for Al_2O_3 prepared by igniting various salts at low temperatures. These showed exothermal changes near

800° and 1100°. In the discussion E. W. Washburn points out that there is an endothermal change of the quartz at 575° which has modified the author's results.

389. Effects of firing temperature on strength of fireclay and stoneware bodies.

H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **4**, 366–74 (1921).—Four clays were studied as to cross-breaking strength, porosity, and shrinkage after firing to different temperatures. Apparently clays of this general type develop maximum strength on firing to cone 8 even though porosity and shrinkage data show the bodies to be under- or over-fired at this temperature. Bodies which develop maximum shrinkage and minimum porosity at cone 8 have a greater ratio of fired strength to dry strength when fired to cone 8 than those bodies which are under- or over-fired at cone 8.

390. Properties of refractories under load at high temperatures.

M. E. L. DUPUY. *Ceramique*, **25**, 308–10 (1922); *Ceram. Abs.*, **2**, 16 (1923); *C. A.*, **17**, 192 (1923).—Clay had a maximum strength at 1000° when fired to 1250° previous to testing and at 1150° when fired to 1500° before testing. Analysis given. Strength was measured by means of impact, increasing load from zero at the rate of 150 kg. per minute and by static load. The brick after having been crushed resumed, on cooling, a certain degree of solidity, thus indicating that a portion of the constituent had undergone fusion during the test. This is explained by the skeleton theory of refractories in support of which more experiments were carried out.

391. Dry pressing refractory shapes.

L. W. FLOOD. *Brick and Clay Rec.*, **61**, 865 (1922); *Ceram. Abs.*, **2**, 99 (1923); *C. A.*, **17**, 1699 (1923).—A high per cent of plastic clay is not necessary for dry press ware. Moisture content runs about 7%. Advantages claimed for dry press process are: (1) cost of manufacturing reduced, (2) cost of installing driers lessened, (3) ware is more uniform and exact in size, (4) refractoriness of some clays is increased, (5) uniform size of ware reduces the fire clay used in the joints, (6) large refractory shapes withstand thermal shocks better, and (7) dry press ware is a poorer conductor of heat.

392. Refractory clays of Texas.

J. H. KRUSON. *Jour. Amer. Ceram. Soc.*, **5**, 643–45 (1922).—Describes the high silica refractory clays of Texas.

393. Disintegration of blast furnace linings.

P. O. MENKE. *Blast Fur. Steel Plant*, **10**, 116–18 (1922); *Ceram. Abs.*, **1**, 181 (1922).—Furnace linings have expanded so as to cause bursting of the furnace shells. These linings were ordinarily found to be vitrified and of good character for a penetration of 2 to 4 inches; then a softening of the brick took place which often carried to within 4 to 5 inches of the outer shell. The softened portion contained up to 50% Zn in the form of oxide and metal. Hand made or steam pressed brick made no difference in the penetrating action of the zinc.

394. Refractory clays of Illinois.

C. W. PARMELEE. *Jour. Amer. Ceram. Soc.*, **5**, 685–94 (1922).—A brief discussion of the geological occurrence of the fireclay beds in Illinois and results of testing samples which are typical of various areas.

395. Fire clays of the eastern coalfield of Kentucky.

H. RIES. *Jour. Amer. Ceram. Soc.*, **5**, 397 (1922).—The eastern coalfield of Kentucky contains two horizons of workable refractory clays. One of these bearing flint, semiflint, and plastic clay is definitely proven to be of upper Pottsville age, and rests unconformably on the Mississippian formations. The other fire clay is of less commercial value. A number of points, not hitherto emphasized or noted, are described.

396. The microscopic examination of the mineral constituents of some American clays.

H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **5** [1], 3–27 (1922).—English kaolin is chiefly crystallized being similar in this respect to the N. C. kaolin. Georgia, S. Carolina, and some Pennsylvania clays consist largely of colloidal kaolin, hence their different physical properties. The total tonnage of crystallized kaolin in the U. S. is apparently quite limited. The objectionable abrasive qualities of the American clays can be overcome by better refining, but the colloidal particles cannot be changed to crystalline. The chief minerals found were muscovite, quartz, tourmaline, biotite, zircon, alkali, feldspar, plagioclase, rutile, hydrated silica, and hematite.

397. Effect of a few typical refractory clays on the behavior of chamottes at high temperatures.

W. STEGER. *Ber. deut. keram. Ges.*, **3**, 250–56 (1922); *Chimie et Ind.*, **12**, 1066 (1924); *C. A.*, **19**, 1038 (1925).

398. Retorts for zinc ores.

J. P. VARIAN. *Eng. Min. Jour.*, **113**, 363 (1922); *Ceram. Abs.*, **1**, 208 (1922); *C. A.*, **16**, 1643 (1922).—Varian recommends sizing of grog to minimize voids. Each grain of grog must be coated with a thin film of clay and to accomplish this the clay is soaked with H_2O in a large tank to form a thin mud. The tank should have a mixing device and sized grog should be added in definite amounts.

399. Manufacture of fireclay refractories.

A. G. WIKOFF. *Chem. Met. Eng.*, **27**, 505 (1922); *Ceram. Abs.*, **2**, 15 (1923).—Outline of plant operations at the Evens and Howard Fire Brick Co., St. Louis.

400. Fireclay refractories.

A. G. WIKOFF. *Chem. Met. Eng.*, **27**, 969–71 (1922).—An outline of manufacturing operations at the Laclede-Christy Clay Products Co. at St. Louis.

401. Setting a Lancashire boiler.

ANON. *Brit. Clayworker*, **32**, 119 (1923).—Special blocks for setting boilers are described.

402. Blue mountain refractories.

ANON. *Min. Eng. Rec.*, **27**, 78 (1923); *Ceram. Abs.*, **2**, 198 (1923).—Tests made on the clays from the property of these refractories at Whonnock, B. C., show they carry 51.2% aluminum oxide, thus approaching bauxite. These clays are said to be the richest clays in aluminum, known to exist in Canada.

403. The firebrick materials of Pennsylvania.

GEORGE H. ASHLEY. *Jour. Amer. Ceram. Soc.*, **6**, 837–49 (1923).—Pennsylvania produced over 40% of all clay fire brick and over 70% of all silica fire brick made in the United States. In 1920 Pennsylvania produced and sold fire clay worth nearly 2 million, fireclay brick worth nearly 22 million, and silica brick worth over 10½ million, a total of 34½ million dollars worth of brick and clay. Three kinds of material are used for the manufacture of this fire brick. (1) Soft fire clay from one horizon northwest of Pittsburgh and from the "main clay" of the Pittsburgh bed south of Pittsburgh. (2) Hard or flint clay which occurs in many counties of the State. The hard clays are described as occurring at a limited number of horizons in the Allegheny formation or "Lower Productive Coal Measures," as being irregular in thickness and distribution, ranging from a feather-edge to 15 or 20 feet in thickness and being of two types: "block" clay in which the structure is homogeneous, and "nodular" clay in which the structure is gnarly or knotty. Brief reference is made to the principal flint clay deposits of the

State. (3) The third source of material for fire brick is ganister rock, a pure white quartzite occurring as a massive bedded sandstone at the base of the Silurian series and exposed abundantly in the zig-zag ridges across the central part of the State and as a similar white quartzite at the base of the Cambrian in the southeastern part of the State. A series of tests of flint clays and of soft clays used to mix with the flint clays is appended. These are derived mainly from Clearfield County which is the leading flint clay county.

404. Refractories for air furnaces.

C. E. BALES. *Foundry*, **51**, 112–17 (1923); *C. A.*, **17**, 1538 (1923).—Fire brick deteriorate rapidly when used in a reducing atmosphere. The Fe is reduced to ferrous state forming a powerful flux. Longer firing also increases the density, which decreases the resistance to spalling. Brick for bungs or roofs should contain at least 38% Al_2O_3, be coarse grained, soft fired and open textured. Brick for wall use should be the opposite.

405. Refractory clays of the Alberhill, California, deposits.

B. M. BURCHFIEL. *Jour. Amer. Ceram. Soc.*, **6**, 1167–75 (1923); *C. A.*, **18**, 738 (1924). —Eleven clays are described from which refractories for practically all purposes can be made.

406. Making stiff-mud fire brick.

A. C. COCHRAN. *Brick and Clay Rec.*, **62**, 852–54 (1923); *Ceram. Abs.*, **2**, 223 (1923). —Plastic clay is ground as fine as possible, but flint and calcined clay is usually ground to pass $\frac{3}{6}$ to $\frac{5}{16}$ in. screen. Weathering clay improves it; additions of calcined clay greatly reduce spalling. Mixture should be tempered thoroughly, with moisture content at a maximum instead of a minimum. Avoid the use of excessive oil as it causes cracking.

407. The corrosion of fire clay by alkali-lead oxide glass.

EDITH GROTH, F. W. HODKIN, DONALD TURNER, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **7**, 218–27 (1923); *C. A.*, **18**, 889 (1924).—Method given. Different clays have different resistances. A K batch is generally more corrosive than a Na batch. Most of the corrosion took place in the early stages of the glass heating. Practically no more corrosion took place in 24 hours than in 3½ hours. Cullet melts caused only about ¼ to ½ the corrosion that batch melts gave. Firing the pots for 24 hours at 1350° gave better resistance than 3½ hours. High Al_2O_3 alone does not bestow resistance to corrosion on a fire clay nor alone does low porosity. Most of the corrosion is due to alkali salts in the batch.

408. Fireclay refractories.

R. M. HOWE. *Jour. Amer. Ceram. Soc.*, **6**, 275–77 (1923).—A historical sketch is given.

409. Effect of time and temperature upon the chlorination of flint fire clay.

HERBERT F. KRIEGE. *Jour. Amer. Ceram. Soc.*, **6**, 850–53 (1923).—An experiment is described in which flint fire clays were chlorinated at fixed temperatures between 500°C and 950°C and for varying periods of time. A replaceable condensing system permitted the rate of formation of the volatile chlorides to be studied.

410. The common refractories.

C. E. MOORE. *Metal Ind.* (London), **23**, 458 (1923); *Ceram. Abs.*, **3**, 46 (1924); *C. A.*, **18**, 1040 (1924).—Volume changes in fire brick at different temperatures involve buckling of arches. An increasing number of semisilica brick containing 80% of SiO_2 are being used.

411. The behavior of fire brick in malleable iron furnace bungs.

H. G. SCHURECHT AND H. W. DOUDA. *Jour. Amer. Ceram. Soc.*, **6**, 1232–41 (1923); *C. A.*, **18**, 739 (1924).—Best results were secured with bricks which showed a spalling loss of less than 10%, a porosity of 15–28%, a density of 1.9–2.3, and a ratio of $RO_2 : RO + R_2O_3$ of 1.5–2.60. Load tests and softening points were not reliable criteria of serviceability. SiC brick withstood more heats than did any fire brick but their high heat conductivity is objectionable.

412. The requirements of fire brick suited to malleable practice.

H. A. SCHWARTZ AND A. F. GORTON. *Jour. Amer. Ceram. Soc.*, **6**, 1094–97 (1923); *C. A.*, **17**, 3911 (1923).—Causes for failure of refractory brick: (1) melting, (2) spalling, (3) fluxing, (4) erosion, (5) change of shape, (6) deformation under load. Discusses the destructive forces present in each part of the air furnace used for malleable iron. All but the last force listed above, deformation under load, have an action in the air furnace.

413. The flint clay situation in Ohio.

WILBUR STOUT. *Jour. Amer. Ceram. Soc.*, **6**, 1153–59 (1923).—A discussion of the flint clays of Ohio with special reference to Sciotoville, Lower Kittanning, Oak Hill and Lower Freeport clays. It is shown that (1) flint clay beds of high heat duty quality in Ohio are small but well-defined; (2) there is small prospect of finding other deposits under deeper covering; (3) the most easily available material is exhausted; (4) the present supply will last present plants at least fifty years but will not permit much increased consumption; (5) conservation of high heat duty clays should begin now before supply is gone.

414. Broken saggers as grog.

ANON. *Brit. Clayworker*, **33**, 114 (1924); *Ceram. Abs.*, **3**, 319 (1924).—The use of broken saggers as grog for fire brick is recommended. This has the advantage over other grog in that it has been repeatedly fired.

415. Special brick lines.

ANON. *Brit. Clayworker*, **33**, 231–32 (1924); *Ceram. Abs.*, **4**, 77 (1925).—The use of brick for iron and steel ladles is discussed.

416. Refractory minerals produced at Kanakura mine.

ANON. *Jour. Japan Ceram. Assn.*, **32**, 251 (1924); *C. A.*, **19**, 1335 (1925).—A white mineral, called "Toa-hakuseki" is produced with diaspore. Both minerals are considered decomposition products of porphyrite. "Tao-hakuseki" analysed: H_2O 24.28, SiO_2 39.38, Fe_2O_3 0, Al_2O_3 36.94, CaO 0, MgO trace, and alkali 0. It is probable that the mineral is newtonite ($Al_2O_3.2SiO_2.4H_2O$) contaminated with a little diaspore ($Al_2O_3.H_2O$).

417. Checker bricks for resisting alkaline slags.

M. C. BOOZE AND F. C. FLINT. *Jour. Amer. Ceram. Soc.*, **7**, 594 (1924); *Trans. Ceram. Soc.* (Eng.), **23**, 73A (1924); *C. A.*, **18**, 3259 (1924).—Checker bricks were placed in the top of regenerators of two glass tank furnaces. They ranged in composition from silica brick to high alumina bricks and from a medium to a very dense texture. The amount of corrosion was found to vary directly with the silica content. In the regenerator operating at the lower temperature the corrosive dust appeared to have little action on the high alumina brick while it fused to a glass on the highly siliceous material. On the other hand it adhered to the high alumina bricks and tended to clog the regenerator working at the higher temperature and appeared to flux and drain off those high in silica.

418. Refractory article and methods of making the same.

WILLIAM A. HARTY. U. S. 1,473,853, Jan. 22, 1924; *Ceram. Abs.*, **3**, 103 (1924).—A refractory article containing fire clay and fused silica.

419. Note on secondary expansion of flint clay.

FRED A. HARVEY. *Jour. Amer. Ceram. Soc.*, **7**, 455–56 (1924).—Certain flint fire clays show a secondary expansion, which may amount to several per cent, at a temperature much below that at which dangerous expansion begins. Some specifications discriminate unjustly against brick containing fire clays of this type.

420. Note on the influence of rapid cooling on the reversible expansion of fire clay. I.

H. S. HOULDSWORTH. *Jour. Soc. Glass Tech.*, **8**, 30–36 (1924); *Ceram. Abs* .,**3**, 266 (1924); *C. A.*, **18**, 2588 (1924).—Fireclay test pieces were fired to cone 9 in 3 hours and held for 2 hours. Then one piece was air cooled. Practically no difference in expansion was found. Firing at cone 14 for 2 hours and cooling in the same way gave a more rapid rate of expansion from 100–200° and 500–600° for the slowly cooled specimens. Reheating the chilled test pieces to 950° had no effect, but reheating to cone 12 and slow cooling raised the expansion.

421. The influence of exposure on the chemical and physical properties of certain fire clays.

W. HUGILL AND W. J. REES. *Jour. Soc. Chem. Ind.*, **43**, 985 (1924); *Ceram. Abs.*, **3**, 350 (1924).—Samples of 3 clays, 2 of them sandy and micaceous, the other fine grained and more aluminous were weathered for a year. Small brick were made from the exposed and from unexposed samples. Exposure improved the working properties of the siliceous clays, but not materially the aluminous, though some impurities were removed. Bacteria seem to promote the decomposition of sulphides in clays, and possibly such decomposition may be accelerated by innoculations.

422. Sillimanite development in some typical clays.

H. M. KRAMER. *Jour. Amer. Ceram. Soc.*, **7**, 726–34 (1924); *C. A.*, **18**, 3459 (1924).—A ball clay, a flint fire clay, a plastic fire clay, a kaolin, and a sample of kaolinite were studied. Conclusions: (1) sillimanite development seems gradual rather than sudden; (2) weakness at high temperature is probably not due so much to molecular rearrangement as to attendant fluidity; (3) sillimanite formation seems independent of the presence or absence of impurities; (4) when sillimanite develops from a kaolinite crystal the direction of elongation remains the same. The discovery of Bowen and Greig (*This Bibliography*, p. 74) that $3Al_2O_3$–$2SiO_2$ rather than Al_2O_3–SiO_2 is the only binary compound in the Al_2O_3 series that does not change the value of this petrographic study or affect the conclusions drawn. The interpretations apply to the development of $3Al_2O_3$–$2SiO_2$ as well.

423. Refractory clays and shales of Indiana.

W. N. LOGAN. *Jour. Amer. Ceram. Soc.*, **7**, 201–206 (1924).—L. gives distribution, amount, and character of refractory clays in Indiana with data on properties of product.

424. Some causes of the variation in the sizes of refractories.

J. W. MELLOR. *Gas. Jour. Suppl.*, pp. 27–28, July 9, 1924; *C. A.*, **19**, 3358 (1925).—The best temperature for maturing a brick is that at which the contraction temperature curve shows that any further rise in temperature produces insignificant changes in volume up to the highest temperature at which the brick will be used. If the bricks are set too closely in the kiln the inequalities of heating are emphasized.

425. Discussion on the disintegration of clay refractories in iron blast furnaces.

S. M. PHELPS. *Jour. Amer. Ceram. Soc.*, **7**, 716–17 (1924); *C. A.*, **18**, 3263 (1924). —Treatment of the fire clay, by weathering or otherwise to remove the objectionable Fe compound, is recommended.

426. Fireclay brick: their manufacture, properties, uses, and specifications.

ANON. Bur. Stand., *Circ.*, **282** (1925).—The circular contains a brief history of the manufacture of fireclay brick and of the growth of technical research and of the industry in this country, together with essential information regarding the manufacture of fireclay brick and the classifications, properties, and uses of the finished product. Since the quality of fireclay brick and the uses to which they are adapted depend largely on the raw clays used, the paper also contains a brief discussion of the geology of these materials, their classification, and the characteristic properties of each class. In addition, the history of the development of the Government Master Specification for Fireclay Brick, together with this specification and a list of the principal references to literature on the subject of fireclay brick, is given.

427. Modern methods of batch preparation in the firebrick industry.

G. BENFREY. *Feuerfest*, **1**, 1 (1925); *Ceram. Abs.*, **4**, 195 (1925).—Machinery supplants manual methods and improves the quality of the batch by (1) more intimate mixing, (2) more uniform water content, (3) elimination of harmful impurities. In contrast to the old open air weathering and pit mixing method the modern tendency is to dry and to grind the raw materials. A description is given of a typical installation built by the Georg Dorst Mach. Wks. Oberlind S* M for the Frieberg Porcelain Co. and used for the preparation of sagger mixture. The plant is divided into 3 units, (1) crushing and separating of grog, (2) grinding of clay, and (3) mixing. The clay is ground on a dry pan and automatically screened and carried by bucket elevators to storage bins. Grog passes through a roll crusher, elevator, and revolving screen which deposits the material into 3 bins according to fineness. The storage bins discharge their contents through special measuring devices into a conveyor which carries the material to a horizontal mixer where water is added and from there to a horizontal pug mill.

428. The chemical and physical properties of fire clays from various producing districts.

M. C. BOOZE. *Jour. Amer. Ceram. Soc.*, **8**, 655–65 (1925); *C. A.*, **19**, 3574 (1925).—Chemical analysis, fusion points, and firing characteristics of a number of flint and plastic clays from various districts are given and uses discussed.

429. Refractories for oil-burning boiler.

T. S. CURTIS. *Mech. Eng.*, **67**, 299 (1925); *Ceram. Abs.*, **4**, 1671 (1925).—Two causes for short life of fire brick in oil burning boilers are (1) softening under load at temperatures hundreds of degrees below melting point, and (2) spalling. Softening is due to incipient vitrification. Spalling is exaggerated by rapid heating and cooling. A third destructive influence is the throbbing or pulsating of the oil flame. A brick has been produced from purified California clays which is dense, free from impurities, and glazed with a sillimanite coating; an interlocking shape is provided to minimize the destructive effect of the vibration of the oil flame.

430. Suggestions on boiler furnace design.

C. M. GARLAND. *Power*, **61**, 176 (1925); *Ceram. Abs.*, **4**, 134 (1925).—Furnace temperature is intimately related to the combined efficiency, the capacity developed, and the life of the furnace lining. The highest temperature possible consistent with reasonable refractory life should be maintained. All heat transactions occurring within the furnace and boiler setting will be dependent upon high temperature for the greatest

efficiency, and the only limit at the present time is the life of the refractory. Too long life to the refractories indicates uneconomical operation. Radiation and conduction losses are discussed together with losses caused by stratification of gases and the proper type of stoker to prevent stratification.

431. Testing of fireclay brick with special reference to their use in coal-fired boiler settings.

R. F. GELLER. Bur. Stand., *Tech. Paper*, **279**, 97–139 (1925); *Ceram. Abs.*, **4**, 311 (1925); *C. A.*, **19**, 1934 (1925).—Forty-two brands subjected to (1) endurance (with and without load), (2) reheating, (3) quenching, (4) load, and (5) softening point tests. Each brick was analyzed chemically and several examined petrographically. It was found that a close relation existed between data obtained in endurance, reheating, quenching, and softening point tests, and that these depended to a remarkable extent on the chemical composition. A brick surviving the quenching test successfully was found to fit closely into narrow limits of the other tests. The result favored the dry press method of manufacture. The brick fail primarily in service because of erosion indicating lack of refractoriness and resistance to the fluxing action of molten coal ash. The one exception is the suspended arch in which the refractories fail mainly by spalling

432. Finishing of fired refractories.

C. GRUPP. *Tonind. Ztg.*, **49**, 351 (1925); *Ceram. Abs.*, **4**, 312 (1925).—Regarding the milling of brick.

433. Manufacture of refractories by the dry-press method.

E. HAGAR. *Jour. Amer. Ceram. Soc.*, **8**, 122–24 (1925); *C. A.*, **19**, 1038 (1925).—Dry pressing is a recent development in ordinary refractories. It reduces the cost and gives better ware.

434. The softening of raw materials used in the refractory industry at high temperatures.

H. HIRSCH. *Keram. Rund.*, **33**, 279–84 (1925); *Ceram. Abs.*, **4**, 195 (1925).—The transverse resistance of refractory clays to load at high temperatures was studied. It was found that clays having a higher SiO_2 content than kaolinite and those having a lower content in certain cases are more resistant to load at high temperatures than those clays having a ratio of SiO_2 and Al_2O_3 equal to that of kaolinite. The presence of Fe and alkalis in the clay were found greatly to reduce their resistance to load at high temperatures.

435. Classifying refractories.

L. LITINSKY. *Feuerfest*, **1**, 37 (1925); *Blast Fur. Steel Plant*, **13**, 9 (1925); *Ceram. Abs.*, **4**, 278 (1925).—(1) Silica brick (high silica content). (2) Chamotte brick (high alumina content). (3) Silica-chamotte brick (clay base with free silica). (4) Clay brick of sandy clay and no grog. (5) Carbonaceous brick. (6) Unclassified (special oxides). Basic brick depend for refractoriness on oxides and contain no free silica. Acid brick depend for refractoriness on high SiO_2 content.

436. Refractories for boilers.

L. LITINSKY. *Feuerungstech.*, **13**, 70 (1925); *Ceram. Abs.*, **4**, 105 (1925).—Refractories classified according to position in furnace as follows: (1) material in close contact with the fuel bed; (2) material in contact with flame and hot gases (3) material in contact with hot gases only. Conditions encountered by boiler refractories are (*a*) high temperature, (*b*) mechanical strains, (*c*) rapid temperature changes, (*d*) changes in volume, (*e*) chemical action. To prevent volume changes: (1) fire product sufficiently high, (2) calcine non-plastic ingredients at high enough temperature, (3) counteract high shrinkage of basic material by addition of quartz which has a tendency to expand,

or vice versa. Considers the requirements for service in boilers, the effect and desirability of the physical properties, action of salt fumes. Quotes suggested specifications from *Trans. Assoc. Electric Power Stations*, 1923.

437. The action of arsenic compounds on tank blocks.

D. J. McSwiney. *Jour. Amer. Ceram. Soc.*, **8**, 307–309 (1925); *C. A.*, **19**, 1933 (1925).—Comparing average life on Na–Ca glass tanks melting green glass with those melting flint glass, decolorized by Se (other conditions being similar), shows that the life of the Se flint tank is much shorter than that of the green tank. This is independent of the amount of Se but increasing the amount of As used in conjunction with the Se greatly shortens tank life.

438. Flux block or fire brick for smelters.

E. B. Prentice. *Ceram. Ind.*, **5**, 235 (1925); *Ceram. Abs.*, **4**, 343 (1925).—Lack of standardized size prevents the use of blocks. Standard fire bricks should be used with very thin joints.

439. Notes on testing for refractoriness and after-contraction; a few experiments with refractories in vertical retorts.

T. F. Rhead and R. E. Jefferson. *Gas Jour.*, **171**, 31–41 (1925); *Gas World*, **82**, 625–28 (1925); *Ceram. Abs.*, **4**, 309 (1925).—Discussion of refractory tests. Curves of the expansion of the retort are given. Photographs and description of the fluxes of a dismantled retort. Action of the producer gas was well demonstrated. In all retorts near the nozzles in the flue wearing away of the refractory was evident. In some places spalling was bad while others had little or none. Bad fusion was evident in firebrick retorts and slight in siliceous. Practical indications were obtained on the regulation of the rate of rise of the temperature during the initial heating of a setting, the need of accurate limitations of temperature below a prescribed maximum, and a method of applying load test results to industrial considerations.

440. Refractoriness of clays.

H. Salmang. *Archiv. für Wärmewirtschaft*, **6**, 241–42 (1925); *Ceram. Abs.*, **4**, 343 (1925).—The factors affecting the value of clays for high temperature services are discussed. For testing refractory clays, the softening point determination is more reliable than chemical analysis but may be from 300 to 500°C above the maximum safe temperature for service under load.

441. Some fundamental principles governing the corrosion of a fireclay refractory by a glass.

R. B. Sosman. *Jour. Amer. Ceram. Soc.*, **8**, 191–204 (1925); *C. A.*, **19**, 1762 (1925). —An excellent summary. Emphasis is placed on the important distinction between equilibrium and the rate of reaction. This consideration is on the basis of the phase rule.

442. The temperature gradients obtained by different rates of heating in unfired fireclay bricks, between 15°C and 250°C.

L. S. Theobald and A. T. Green. *Trans. Ceram. Soc.* (Eng.), **24**, 105–23 (1925); *Ceram. Abs.*, **4**, 345 (1925).—The temperature gradients obtained by different rates of heating in unfired clay brick between 15° and 250°C have been investigated by a method which determines the exterior and interior temperatures. The "gradient-ratio" curves show that the maximum value of the ratio, the interior temperature of the brick lies between 117° and 121°C. This fact suggests that all the mechanical and hygroscopic water has been expelled when this interior temperature has been reached. From data obtained, the minimum time required for the safe rate of heating the green brick to a

temperature of 250°C has been considered for 3 types of brick investigated under the particular conditions described.

443. Observations on the elimination of carbonaceous matter from fireclay bricks.

L. S. THEOBALD AND A. T. GREEN. *Trans. Ceram. Soc.* (Eng.), **24**, 159–69 (1925); *Ceram. Abs.*, **4**, 345 (1925).—No change in the carbonaceous material is apparent in the test specimens at temperatures below 500°C but at 600° oxidation has, undoubtedly, commenced. The cores of the draw trials become blacker as the time at 600° is increased indicating that further changes are taking place in the carbonaceous matter. At 650°C, a white ring, which develops into a yellow area, follows the removal of the carbonaceous matter. Under deficient air supply conditions at 600°C a yellowish area replaces the carbon. On heating to 750° the shade of the interior darkens as if a diffusion of carbon had taken place. Reduction of the iron may contribute to this change. The black cores at this temperature are definitely replaced by persistent yellow areas and a more prolonged soaking at 750°C would not remove them.

444. Some features of tank block comparisons.

F. S. THOMPSON AND H. I. VORMELKER. *Jour. Amer. Ceram. Soc.*, **8**, 611–17 (1925); *C. A.*, **19**, 3575 (1925).—Life of tank blocks is increased by lower furnace temperatures obtained by increasing the area of melting chamber and by insulation of the walls. Analyses and physical tests of clays and blocks are given; results of service tests are also given but "data does not warrant conclusions."

445. A treatise on Missouri clays.

M. H. THORNBERRY. School of Mines and Univ. of Mo., *Bull.*, **8**, 9–69 (1925); *Ceram. Abs.*, **5**, 33 (1926); *C. A.*, **19**, 3357 (1925).—The clays of Missouri are described in detail with analyses and physical tests.

446. Attack of fire brick by combustion products.

D. J. VAN WIJK, JR. *Chem. Weekblad*, **22**, 16–18 (1925); *Ceram. Abs.*, **4**, 221 (1925); *C. A.*, **19**, 1934 (1925).—The principal factor in the corrosion of refractory material of a furnace is the ash of the fire; high Fe or Al content of the fuel is particularly objectionable. Good fire brick should have an Al_2O_3/SiO_2 ratio as near to 71/29 (mullite, $3Al_2O_3.2SiO_2$ according to Bowen and Greig, (*This Bibliography*, p. 74), as practically possible, low Fe, Na, K, and Ca content and low porosity.

447. Refractory industry in Canada.

W. G. WORCESTER. *Contract Rec. and Eng. News*, **39**, 111 (1925); *Ceram. Abs.*, **4**, 135 (1925).—Important clay deposits in Canada are at Clayburn, B. C., Dirt Hills, Sask., and the siliceous kaolinite at St. Remi, P. Q. The Saskatchewan clays are just being developed. A trial of the products by 2 railroads showed them superior to many imported refractories.

ALUMINOUS REFRACTORIES

448. The dephosphorization of iron by bauxite.

ANON. *Rev. des Mines et de la Met.* [2], 9 (1881).—Bauxite as a refractory for steel furnaces.

449. Electrically fused alumina "alundum" as a refractory.

L. E. SAUNDERS. *Met. Chem. Eng.*, 9 [5], 257 (1911).—Two forms of alundum are used for the manufacture of refractories: a white crystalline product with less than 1% impurity, and a reddish-brown vitreous material with 6–8% impurity; the impurities

in both cases are oxides of Fe, Ti, and Si. The properties of these two varieties are: melting point (1) 2050–2100°, (2) 2000–2050°; coefficient of linear expansion, (1) 0.0000078, (2) 0.0000085. The thermal conductivity is about twice that of Marquardt porcelain and about 3 to 4 times that of most fire clays. Hardness is between 9 and 10. Specific gravity is 3.93–4.00. Both forms are soluble with difficulty in both basic and acid slags, more readily in acid slags. Articles are made by mixing alundum grains with a ceramic binding material, molding into suitable shape, and firing in kilns. The resulting articles are more refractory than the binding agents; none melt below 1950°. The properties of bonded mixtures are about the same as those of alundum grains. All products are quite porous. The electric resistance in ohms per cm. cube is 47,600,000 at 535°; 4,900,000 at 721°; 2,400,000 at 908°; and 750,000 at 1040°. Muffles, tubes, crucibles, etc., are described. Alundum bricks are being tried. Cones made from commercial refractory bricks melted in the following order, alundum being the most infusible: (1) silica, (2) chrome, (3) bauxite, (4) brown magnesite A, (5) brown magnesite B, (6) Grecian magnesite, (7) alundum. Alundum will not soften until within 100° of its melting point.

450. Refractory materials for furnace construction.

L. P. KRAUS, JR. U. S. 1,289,049.—Bauxite or similar material is powdered, mixed with twice its volume of ground wood and molded into blocks with H_2O and glucose or other binder. The blocks are dried and then roasted at a temperature (preferably about 160° below melting point) sufficiently high to produce clinkered material in the form of spongy grains with the cleavage planes destroyed. Air is supplied during the heating to oxidize and remove impurities, and after clinkering the material is crushed to the degree of fineness desired for use. Most of the Fe_2O_3 in the bauxite is eliminated during the process.

451. New refractory materials from fused bauxite.

N. LESCESNE. *Ceramique*, **20**, 41 (1917); *Trans. Ceram. Soc.* (Eng.), **18**, 86A (1919). —Relates to a new method of fusing bauxite and its application in the production of special refractories.

452. Refractory and abrasive matter, a new refractory called corundite.

A. BIGOT. *Engineering*, **105**, 619–20 (1918); *Jour. Amer. Ceram. Soc.*, **3**, 160 (1920); *C. A.*, **12**, 2242 (1918).—A patent for a new process of fusing bauxite, taken out in 1914, by N. Lecesne, a French engineer. Bauxite is heated in a cupola furnace with anthracite and blowing air in the bottom. White bauxite is very refractory, and red bauxite is a powerful abrasive. Bauxite brick expand slightly at 1700–1730° and above 1750° have a slight shrinkage, about 3% at 1850°C.

453. Protecting refractory furnace linings.

H. T. CHAPPELL. U. S. 1,308,481, July 1, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 763 (1919).—Refractory furnace linings containing silica are protected from fusion and disintegration by supplying finely divided calcined and leached alunite to such linings when they are at such a temperature as to be soft and partly fused.

454. Process of purifying aluminous materials.

O. HUTCHINS. U. S. 1,310,342, July 15, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 849 (1919). —This process relates to the production of an aluminous abrasive material of relative high purity, containing not over 1% each of Fe_2O_3, TiO_2, and SiO_2, and consists in fusing aluminous materials such as bauxite, in the presence of carbon insufficient in amount to reduce all the Fe_2O_3, TiO_2, and SiO_2 contained therein, separating the aluminous product from the reduced impurities and re-fusing the product in the presence of sufficient carbon to cause a further reduction of the above oxides.

455. Refractory properties of aluminous materials.

H. LeChatelier and B. Bogitch. *Compt. rend.*, **169**, 495–99 (1919); *C. A.*, **14**, 213 (1920).—Bauxite brick cannot be used in arches of steel furnaces on account of high shrinkage and porosity. They are less easily corroded in lead furnaces than ordinary brick. Remove Fe_2O_3 and SiO_2 and fuse to remove shrinkage and lower porosity, or fuse in cupola to form corundite with impurities present. Free from spalling. Results of compression tests.

456. Note on the load behavior of aluminous refractories.

A. V. Bleininger. *Jour. Amer. Ceram. Soc.*, **3**, 155–57 (1920); *C. A.*, **14**, 1742 (1920).—Sillimanite mixtures were fired to cone 20. For plastic bond, a mixture of equal parts of plastic fire clay and N. C. kaolin were used. Results proved that high Al_2O_3 refractories are not necessarily poor in resistance to load, but previous thermal history is important. Hard firing is essential.

457. The Malinite process for the production of sillimanite refractories.

A. Malinovszky. *Jour. Amer. Ceram. Soc.*, **3**, 40–68 (1920); *C. A.*, **14**, 1742 (1920). —Sillimanite is a neutral refractory and valuable for steel furnaces where high temperatures and destructive slags are employed. The Malinite process consists in smelting an Al silicate in a cupola furnace together with a reducing agent; the SiO_2 may be volatized out to the amount to form sillimanite. Details of reports on microscopic examination are given. Produces very uniform product.

458. The commercial synthesis of sillimanite.

Andrew Malinovszky. *Chem. Met. Eng.*, **22**, 851 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 762 (1920).—A description of a cupola process for fusing alumina and silica to form sillimanite crystals. The reactions consist of forming carbides under reducing and combusting them under oxidizing conditions. (See preceding abstract.)

459. Behavior of fire brick in malleable furnace bungs.

H. G. Schurecht. *Jour. Amer. Ceram. Soc.*, **3**, 556–59 (1920); *C. A.*, **14**, 3141 (1920).—Preliminaty tests indicate that high Al_2O_3 bricks with high bulk specific gravity and low porosity are most desirable.

460. Corrosion of coke-oven walls.

H. V. Thompson. *Jour. Amer. Ceram. Soc.*, **3**, 690 (1920); *Pottery*, **45**, 770 (1920). —Highly aluminous clays developing a large proportion of sillimanite are much more resistant to salt attack than ordinary fire clay. Possibility of aluminous clay for coke-oven walls discussed.

461. Artificial corundum.

Anon. *Tonind. Ztg.*, **45**, 1135–36 (1921); *Ceram. Abs.*, **1**, 69 (1922).—In 1894 E. Moyat first made artificial corundum for the firm of Mayer and Schmidt. This material was free from many defects of the natural corundum and soon became widely used as an abrasive. About the same time Acheson discovered Carborundum which also became popular as a refractory. The Moyat process for the manufacture of artificial corundum (Ger. pat. 85,021, 1896, class 12) was based upon the electric melting of emery, bauxite, etc., and the reduction of impurities as Fe_2O_3, SiO_2, and TiO_2 with coal or charcoal. Al_2O_3 is not reduced by this process while the impurities are, and as a result the impurities are reduced, float to the top, and are easily picked off. The purified Al_2O_3 crystallizes to brown to ruby crystals on cooling. During the war the production of this material became an important industry in Germany where it is known as "corraffin."

462. Employment of aluminothermic corundum as a refractory product.

A. GRANGER. *Bull. Official Direction Recherches Sci. Ind. Inventions*, 297–300 (1921); *Ceram. Abs.*, **1**, 40 (1922); *C. A.*, **15**, 3899 (1921).—Crude corundum, pulverized, washed, treated with H_2SO_4 first hot and then cold until no more action was observed. Then treated with HCl and washed. Several formulas given for mixtures. After firing the product is found to withstand sudden changes in temperature and to bear the temperature of melted platinum without much fusion.

463. Lining for rotary kilns or furnaces.

A. F. MEYERHOFER. Can. 209,766, Mar. 22, 1921; *Jour. Amer. Ceram. Soc.*, **4**, 691 (1921).—The lining consists of an inner layer containing a high percentage of fused alumina and an outer heat-insulating layer.

464. Alumina and bauxite.

R. J. ANDERSON. *Mineral Ind.*, **31**, 8–37 (1922); *Ceram. Abs.*, **3**, 100 (1924).—An article on statistics and changes in technology and uses of alumina for 1922. Diaspore and high alumina clays have nearly taken the place of bauxite for refractories. Large amounts of these clays are being mined in Missouri. Low grade bauxite is used in France for alumina cements. The Everhart process for washing bauxite clays in the presence of small amounts of peptizers has possibilities. Richmond and McDonald obtain a very pure abrasive by melting bauxite in an electric furnace and reducing impurities with carbon. Quantity production of sillimanite has been started. The use of ZrO_2—10% Al_2O_3 for steel furnaces has been examined. Several new methods for producing K and Al sulphates from feldspars and shales have been proposed.

465. The composition and microstructure of clays and fusibility at high temperatures.

L. BERTRAND. *Ceramique*, **25**, 133–37 (1922); *Ceram. Abs.*, **1**, 232 (1922).—The relation between the Al_2O_3 content and fusibility of 101 clays was studied and the results summarized in a table. A maximum Al_2O_3 content is the most refractory.

466. Development of a new refractory.

A. F. GREAVES-WALKER. *Jour. Soc. Chem. Ind.*, **41**, 13–14T (1922); *Ceram. Abs.*, **1**, 208 (1922); *C. A.*, **16**, 1643 (1922).—Quantity production of sillimanite brick has already commenced. Analysis of brick is: SiO_2 6.32%; Al_2O_3 86.10; Fe_2O_3 1.17; CaO 0. 60; alkalis 1. 10; TiO_2 4.53. Pure sillimanite is 37 SiO_2, 63 Al_2O_3 with fusion temperature at 1816°C. The brick compares favorably with SiC under the same conditions.

467. Bauxite and aluminum in 1922.

JAMES K. HILL. U. S. Geol. Surv. (Mineral Resources of the U. S.) (1), 87–96 (1922); *Ceram. Abs.*, **3**, 44 (1924).—The domestic production of bauxite increased 122% in 1922 over 1921. The amount produced was not as great as in 1920. The increase in the eastern fields showed a revival of the aluminum salts industry. The main producing states for bauxite in 1922 were Arkansas and Georgia. In the last few years high alumina clays have been substituted for bauxite in manufacturing refractories. The main source of these clays is Missouri. Three grades of clay containing 55%, 65%, and 75% Al_2O_3 are regularly handled. The U. S. produces more bauxite than the rest of the world. The diaspore deposits of Missouri are being rapidly developed. 40,000 tons of diaspore clay were sold to consumers. Diaspore in crystalline form is of commercial interest. Diaspore can probably be used for the manufacture of abrasives and aluminum salts. Cyanite, sillimanite and andalusite, aluminum silicates containing more than 60% Al_2O_3, can probably be substituted in some cases for diaspore and bauxite. Large deposits of cyanite have been discovered in Wyoming

and Arizona. Alunite is being mined and treated in Utah for potash. Some of the by-product Al_2O_3 is being used for the manufacture of refractories. Some data are also given on the production and consumption of bauxite for the various industries.

468. Sillimanite: a high-grade refractory.

ANON. *Bull. Imp. Inst.*, **21,** 383 (1923); *Ceram. Abs.*, **3,** 15 (1924).—Sillimanite is found commonly in gneisses and crystalline schists and in detrital rocks derived from them, usually disseminated in grains or aggregates of fibers. Recently it has been found in India in the massive variety which is very rare. The deposit is in the Khasia Hills of Assam and is in the form of boulders. Experimental work is being carried on by the Imperial Institute as to its value as a high grade refractory material and if it is successful an attempt will be made to overcome the difficulties of transport and place it on the market. Its valuable properties as a refractory are strength and toughness, high melting point (about 1810°C), and stability up to that temperature, low coefficient of expansion, low electrical conductivity, freedom from volume changes, neutral reaction, and resistivity to corrosive slags and to oxidizing and reducing conditions. Its use is still in the experimental stage. The American Refractories Co. in conjunction with the Mellon Institute has also carried out experiments along this line. Though its first cost would be higher than that of less refractory materials it is probable that its greater durability will more than compensate for the difference.

469. Bauxite (France).

ANON. *Chem. Trade Jour. and Chem. Eng.*, **72,** 668 (1923); *Ceram. Abs.*, **2,** 181 (1923).—France is now the predominant producer of bauxite in Europe and the principal producer of the world before the war, her output of 309,000 T being $\frac{3}{5}$ of the world's output; is now 2nd to the U. S., Arkansas showing the most notable increase.

470. Preparation of super-refractories.

ANON. *Metal Ind.* (London), **23,** 465 (1923); *Ceram. Abs*, **3,** 46 (1924).—Work on the development of refractories from artificial sillimanite is in progress at U. S. Bureau of Mines, Northwest Experiment Station, Seattle, in coöperation with ceramic trade interests. The best compound found is one a little richer in alumina than pure sillimanite.

471. Bonded alumina refractory materials.

M. F. BEECHER. U. S. 1,439,286, Dec. 19; *Ceram. Abs.*, **2,** 132 (1923).—Crystalline Al_2O_3 grains containing slag and oxidation impurities are integrally united by a vitrified ball clay material so that the grains are substantially in contact and shrinkage of the article during firing is minimized. Articles such as fire bricks may be thus formed and are fired above cone 12 until any permanent volume change due to expansion of the material has been completed.

472. Development in the manufacture of refractories of fused alumina.

M. F. BEECHER. *Jour. Amer. Ceram. Soc.*, **6,** 292–94 (1923).—History and use of fused alumina in refractories is given.

473. Laminated super-refractory article.

MILTON F. BEECHER AND MACDONALD C. BOOZE. U. S. 1,448,684, Mar. 20; *Ceram. Abs.*, **2,** 183 (1923).—A laminated refractory article having a facing of bonded refractory material, a reinforcing backing layer of ceramic material which is reactive with an ingredient of the facing, and a neutral intermediate layer intimately joined to and separating the facing and backing layers.

474. High alumina refractories.

J. L. CRAWFORD. *Jour. Amer. Ceram. Soc.*, **6**, 290–91 (1923).—History is given of the special use of high alumina clays.

475. Composition and properties of diaspore, bauxite, and gibbsite.

R. M. HOWE AND R. F. FERGUSON. *Jour. Amer. Ceram. Soc.*, **6**, 495–500 (1923).—Bricks high in Al_2O_3 may be made from diaspore, gibbsite, trihydrate, or bauxite. The fusion points are lowered most by CaO and least by Fe_2O_3 and silica. Firing shrinkage was lowest in those minerals high in SiO_2 and highest in those high in Fe_2O_3. Gibbsite showed a higher firing shrinkage than diaspore. The chief defect of high Al_2O_3 bricks is excessive shrinkage.

476. Refractory composition.

JOHN L. OHMAN. U. S. 1,458,723, June 12; *Ceram. Abs.*, **2**, 226 (1923).—A refractory composition for heat resisting articles, comprising crystalline alumina and crystalline graphite.

477. Refractory composition.

JOHN L. OHMAN. U. S. 1,458,725, June 12; *Ceram. Abs.*, **2**, 226 (1923).—A refractory composition for heat resisting articles, comprising crystalline alumina and fused silicon oxide, and crystalline graphite.

478. Refractory materials.

Z. OLSSON. U. S. 1,442,413, Jan. 16; *Ceram. Abs.*, **2**, 132 (1923).—A refractory material adapted for crucibles or furnace linings is prepared from bauxite 95 and bentonite 5 %.

479. Method for analyzing diaspore clay.

M. H. THORNBERRY. *Jour. Amer. Ceram. Soc.*, **6**, 1261–62 (1923).—The method of analyzing refractories recommended by the A.S.T.M. having proved unsatisfactory for diaspore clays, a change has been made whereby fusion is accomplished by adding C. P. NaOH instead of Na_2CO_3 to the finely ground clay and the mixture heated in a nickel crucible over a Bunsen burner.

480. The analysis of high alumina products.

C. A. UNDERWOOD. *Bull. Amer. Ceram. Soc.*, **2**, 152–61 (1923).—Methods of analysis are given in detail and the several special means required to obtain accurate quantitative results.

481. Diaspore clay of Arkansas and Missouri.

D. C. WYSOR. *Jour. Amer. Ceram. Soc.*, **6**, 501–509 (1923).—A history, analysis, and property description of diaspore of Missouri is given with a discussion of relation between bauxite, diaspore, gibbsite, and the burly flint clays.

482. The system: Al_2O_3–SiO_2

N. L. BOWEN AND J. W. GREIG. *Jour. Amer. Ceram. Soc.*, **7**, 238–54 (1924).—This paper deals with a study of the equilibrium relations of mixtures of pure alumina and silica at high temperatures. The results are expressed concisely in the form of an equilibrium diagram and their bearing on ceramic problems is discussed. The principal feature of the diagram is the absence of the compound $Al_2O_3.SiO_2$, the only compound being $3Al_2O_3.2SiO_2$. Crystals of this latter compound occur in all alumina-silica refractories. The optical properties of these crystals have been determined and are compared with those of sillimanite, $Al_2O_3.SiO_2$, which has hitherto been regarded as the crystalline compound occurring in refractories and clay bodies in general. The be-

havior of natural sillimanite on heating is discussed. See discussion by A. A. Klein, *Bull. Amer. Ceram. Soc.*, **3**, 386–87 (1924).

483. The laboratory testing of aluminous refractories.

R. F. GELLER. *Jour. Amer. Ceram. Soc.*, **7**, 663–69 (1924); *C. A.*, **18**, 3263 (1924).—Eight brands of high Al_2O_3 refractories and two brands of fireclay refractories, all of which are used in service requiring resistance to corrosion of CaO and cement clinker at high temperature were tested. Results show that with aluminous refractories containing over 50% Al_2O_3 (1) the fusing point is cone 34 or above; (2) the constant volume test is useless; (3) the refractory will withstand 18 or more quenchings; (4) the absorption, while generally higher than for refractories containing less than 50% Al_2O_3, is not satisfactory for specification work; (5) the deformation does not exceed 5% under a load of 25 lbs. per sq. in. at 1450°; (6) the softening point of a 1 : 1 mixture of refractory and cement clinker is cone 6 or above.

484. Some properties of clay–sillimanite mixtures.

H. S. HOULDSWORTH. *Jour. Soc. Chem. Ind.*, **43**, 985 (1924); *Ceram. Abs.*, **3**, 350 (1924).—Addition of sillimanite to clay decreases drying and firing shrinkage, increases porosity and when 50% or more is present, increases the refractoriness considerably. A mixture of 95% sillimanite with 5% ball clay has a regular coefficient of expansion from 15° to 1000°. The rapid expansion of fire clays between 100 and 200°C and 500 and 600°C are reduced by the addition of sillimanite. Chemical attack by soda-lime glasses and basic slag is less on a mixture containing more than 50% sillimanite than on fire clay or mixtures with less than 50% sillimanite. Sillimanite bonded with 10 grams ball clay is markedly resistant to chemical attack.

485. Preparation (in the electric furnace) of artificial sillimanite for refractory uses.

C. E. SIMS, HEWITT WILSON, AND H. C. FISHER. *Trans. Amer. Electrochem. Soc.*, **46** (preprint, 1924); *C. A.*, **18**, 3147 (1924).—Gives the preparation of sillimanite from SiO_2 and Al_2O_3 and from clay in the electric furnace. Artificial sillimanite above the ratio of $3Al_2O_3$ to $2SiO_2$ is stony and finely crystallized. Below this ratio it is vitreous. As a refractory the vitreous material is inferior to the stony. The stony sillimanite brick, called sillimanite-corundum brick, stand a higher load test than silica, spall less than either silica or magnesite, last longer than either silica or magnesite in a high-lime or high Fe slag, and are as good as silica in an acid slag. When lime as an impurity in sillimanite exceeds 1.5% it causes a serious reduction in the fusion temperature.

486. Refractory product.

A. P. TAYLOR. U. S. 1,491,567, April 22, 1924; *Ceram. Abs.*, **3**, 221 (1924).—As a new article of manufacture a refractory product consisting substantially of diaspore and kaolin and having the fusing point greater than cone 35, substantially as described.

487. Artificial sillimanite as a refractory.

H. WILSON, C. E. SIMS, AND F. W. SCHROEDER. *Jour. Amer. Ceram. Soc.*, **7**, 842–55, 907–20 (1924); *Ceram. Abs.*, **4**, 16 (1925); *C. A.*, **19**, 712 (1925).—Al_2O_3–SiO_2 mixtures were prepared by fusing quartz, china clay, fire clay, and Al_2O_3 in an electric furnace. With Al_2O_3 under 68%, crystalline sillimanite with glass is produced, and resistance to load at high temperatures is not good. But with Al_2O_3 over 68%, crystalline corundum appears and little or no glass. This is very resistant to load at high temperature when an interlocking, recrystallized bond is developed. It is very resistant to acid slag but not basic. The laboratory-made sillimanite-corundum brick withstood higher temperatures than the best SiO_2, MgO, chrome, fire clay or zirconia.

488. Synthetic sillimanite in ceramic bodies.

T. S. CURTIS. *Jour. Amer. Ceram. Soc.*, **8**, 63–68 (1925); *C. A.*, **19**, 1037 (1925).—A new ceramic product is described in which $3Al_2O_3.2SiO_2$ is the chief constituent. The body is tougher and stronger.

489. Formation of mullite from cyanite, andalusite, and sillimanite.

J. W. GREIG. *Jour. Amer. Ceram. Soc.*, **8**, 465–84 (1925).—This paper deals with a thermal and microscopic study of the decomposition of cyanite, andalusite, and sillimanite to mullite and silica, or to mullite and siliceous liquid. The rates of alteration, the signs of the heat effects accompanying the changes, and the way in which the decompositions take place have been investigated. The bearing on refractories is discussed.

490. Kaolin refractory and process of making the same.

ISAAC HARTER AND ANTHONY M. KOHLER. U. S. 1,530,260, March 17, 1925; *Ceram. Abs.*, **4**, 135 (1925).—A refractory article consisting of particles of kaolin fired at a temperature of not less than 3000°F and bonded with kaolin.

491. The quantitative determination of iron existing as ferrosilicon in artificial corundum.

R. A. HEINDL. *Jour. Amer. Ceram. Soc.*, **8**, 671–76 (1925); *C. A.*, **19**, 3575 (1925).—Determine the total Fe by the combined acid treatment and $KHSO_4$ fusion. Determine the amount of ferric oxide present by the fusion method with $KHSO_4$. Subtract the Fe as ferric oxide from the total Fe and the difference is Fe present as ferrosilicon. Grains of artificial corundum examined showed 0.070–0.171% Fe as ferrosilicon. The coarser grains contain more and the finer less of the ferrosilicon.

492. Bauxite and aluminum.

J. M. HILL. *Eng. Min. Jour.-Press*, **119**, 95 (1925); *Ceram. Abs.*, **4**, 105 (1925).—It is estimated that the domestic production of bauxite in 1924 will be approximately 30% less than that of 1923. Supplies of bauxite were approximately 11% less than in 1923. Bauxite from South America is being more extensively used by makers of chemicals. Exports to Canada and Norway were greater in 1924.

493. Refractory product and method of producing same.

HARRISON P. HOOD. U. S. 1,527,874, Feb. 24, 1925; *Ceram. Abs.*, **4**, 107 (1925).—In the manufacture of refractory products from sillimanite, the method which comprises steps of reducing the sillimanite to a fine powder, mixing with water to form a paste, and then shaping and firing to cause a sintering of the material.

494. Quantitative determination of development of mullite in fired clays by an X-ray method.

L. NAVIAS. *Jour. Amer. Ceram. Soc.*, **8**, 296–302 (1925).—Firing clays alone or with fluxes to high temperatures results in the formation of mullite crystals in a highly siliceous vitreous mass. Quantitatively, the extent to which mullite in clays is developed by firing to cone 10 has been determined for Ivory Fat English ball clay, Great Beam ball clay, Jernigan Tennessee ball clay, M. & M. English ball clay and A–1 English china clay. The method consisted in procuring X-ray patterns by the powder method of the clays fired with feldspar as a flux, using mullite as a reference material. The intensities of the lines in these photographic films were then compared with the intensities of lines obtained from a series of mullite and feldspar mixtures, fired to vitrify the flux. The results given in Table II indicate that each clay develops the maximum quantity of mullite in crystalline form, which the chemical composition of the clay allows.

495. Differentiation between mullite and sillimanite by their X-ray diffraction patterns.

L. NAVIAS AND W. P. DAVEY. *Jour. Amer. Ceram. Soc.*, **8**, 640–47 (1925); *C. A.*, **19**, 3575 (1925).—The X-ray diffraction patterns of pure sillimanite and pure mullite

are shown to be different. By X-ray methods it is shown that the crystallized component of calcined clays is mullite, not sillimanite, a conclusion in agreement with chemical and optical data found in the literature but not in accord with the negative previously reported by several workers in X-ray crystallography.

496. An X-ray study of natural and artificial sillimanite.

JOHN T. NORTON. *Jour. Amer. Ceram. Soc.*, **8**, 401–406 (1925); *C. A.*, **19**, 3574 (1925).—Mechanical mixtures of alumina and silica in the molecular proportions of 1 : 1 and 3 : 2 as well as samples of pure kaolin, have been heated to temperatures above 1500°C and have been examined by the X-ray diffraction method. The diffraction patterns obtained from these samples agree exactly with the pattern given by a sample of natural sillimanite, not only in the position of the diffraction lines but in their relative intensities. This indicates that the regularly arranged atoms of these two compounds must have identical positions. It is concluded that either the two compounds are identical or that each unit of the lattice of one compound contains a definite number of randomly arranged atoms which the other compound does not possess.

497. Changes in the constitution and microstructure of andalusite, cyanite, and sillimanite at high temperatures and their significance in industrial practice.

A. B. PECK. *Jour. Amer. Ceram. Soc.*, **8**, 407–29 (1925).—Owing to their growing commercial importance in the manufacture of refractories and porcelain, the minerals of the sillimanite group (andalusite, cyanite, and sillimanite) were investigated as to their decomposition products and volume changes between cones 10 and 15. Petrographic-microscopic examinations showed that andalusite breaks down at cone 13 into mullite and glass, while cyanite also breaks down into the same components but at cone 12. Sillimanite is not decomposed up to cone 15. The composition of the mullite was checked by chemical analysis. Andalusite shows almost no volume change at dissociation; sillimanite shows a slight expansion up to cone 15; cyanite shows a great expansion and disintegration at dissociation. The practical significance of the behavior of the minerals is discussed as well as their possibilities of use in ceramic ware. Andalusite could be used in the raw state; cyanite would require calcination before use, so that andalusite appears to be best suited for most bodies.

498. New use for sillimanite.

W. J. REES. *Jour. Soc. Chem. Ind.*, **44**, 359 (1925); *Ceram. Abs.*, **4**, 166 (1925); *C. A.*, **19**, 2869 (1925).—Sillimanite may be used for making semi permanent molds for repeated castings in iron, steel, and other metals. The high refractoriness of sillimanite and its small drying and firing shrinkage when bonded with 15 or 20% fire clay render it particularly suitable.

499. Progress report on the use of andalusite as a refractory.

R. TWELLS, JR. *Jour. Amer. Ceram. Soc.*, **8**, 485–92 (1925); *C. A.*, **19**, 3153 (1925). —Its most valuable properties are constancy of volume, good strength under load at fairly high temperatures, resistance to sudden heating and cooling, and the ease with which it can be shaped and bonded. It is self-bonding when fired at about cone 18. Several practical adaptions are described.

MAGNESIA REFRACTORIES

500. Magnesium and calcium compounds as refractory and dephosphorizing compounds.

K. BISCHAF. *Dingl. Polyt. Jour.*, **2** [37], 51–126 (1880).—Deals with the physical properties and particularly with the refractoriness of brick and clinker made of lime and magnesia.

501. Magnesia.

ANON. *Zeits. d. v. deutscher Ing.*, p. 463 (1883).—A refractory material made from the mother liquors from Strassfurt carnallite.

502. The use of magnesite for basic linings.

N. KYELLBERG. *Jernkontovets Ann.*, **44** [7], 389–466 (1890).—Discusses the methods of using dolomite and magnesite refractories in 1889 both for patch work and brick.

503. Our present knowledge of refractory products.

J. BIED. *Ceramique*, **1** [22], 33 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 667 (1919).—A review of the characteristic action of magnesia refractories after dead burning. The composition of raw material, dead burned, and of brick are given. A description of the process for the manufacture of brick is given.

504. Mica schist for lining cupolas and steel-converters.

P. G. H. BOSWELL. *Trans. Ceram. Soc.* (Eng.), **18** [2], 382–88 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 415 (1920).—In British practice the material in common use for lining such furnaces as cupolas and steel converters is so-called "ganister," which consists of a sloppy mixture of broken quartzite or ganister rock and fire clay or ground ganister. Such a mixture is used to a small extent in American foundries, but a large number of works employ a rock belonging to the mica-schist group, which is quarried in Pennsylvania and New Jersey, in each case not far distant from Philadelphia. The rock is fairly hard, and even the foliation surfaces can not be scratched by a knife without some difficulty. Nevertheless, the rock is easily split parallel to the folia and worked into the required shapes. The bulk of the rock is composed of the mineral quartz, the grains being of variable size but not drawn out into lenticles. The rock is thus rather a quartz-schist than a mica-schist. Analysis: SiO_2, 81.58; Al_2O_3, 10.04; Fe_2O_3, 2.24; FeO, 0.32; MgO, 0.19; CaO, 0.22; Na_2O, 0.08; K_2O, 3.38; H_2O^+, 1.74; H_2O^-, 0.27; TiO_2, 0.34. The rock is built by masons into the walls of converters and cupolas, inside the firebrick casing, in the usual way. It should be set with the cleavage edges, and not the faces forming the inner wall. Nevertheless, where the rock had been so set, the material withstood the effects of hot metal.

505. Magnesite in West Australia.

F. R. FELDTMANN. *Mining Mag.*, **21** [4], 240–42 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 1013 (1919).—The magnesite deposits are located near Bulong, about 20 miles east of Kalgoorlie, and on the west side of Lake Yindarlgooda. The district is made up of a complex of highly basic rocks, the major portion of which consists of serpentine with which the magnesite invariably is associated. A few small areas of gabbro or amphibolized gabbro and several large porphyritic dykes make up the minor part of this complex of basic greenstones. In and near the magnesite area a few small dykes are found. East of this greenstone mass is a belt of rocks of plastic origin, known as pebble breccia. Still further to the east is a second area of greenstones less basic than the rocks of the magnesite area. The largest magnesite bearing serpentine area is located about 2¼ miles due east of Bulong and covers about 350 acres, the southern portion of this area being much covered with surface deposits. North of this main mass are several smaller occurrences of the magnesite-bearing serpentine. The largest of these covers about 90 acres. It is possible that other areas may occur further to the north near Mt. Taurus. In the pebble breccias and near the boundary of the serpentine, small lenses of magnesite have been found. According to the author the magnesite in these patches has been dissolved out of the serpentine by surface waters and redeposited in the plastic materials. The magnesite occurs mainly in the serpentine in the form of short veins which are irregular both as to strike and dip. Most of these veins are only

a few inches wide and many of them are threadlike. Where the serpentine is greatly decomposed the veins are very numerous and may be easily quarried. In a few places the magnesite forms a surface deposit which is usually more dircolored than the veins. The largest of these surface deposits extends over a la-ge part of an area of about 15 acres. The proportion of impurities in the magnesite varies considerably as shown by the following analyses:

ANALYSES OF BULONG MAGNESITE

	1	2	3		1	2	3
Magnesia, MgO	47.36	44.96	44.31	Lime, CaO	nil	1.06	nil
Carbon dioxide, CO_2	51.69	49.33	47.76	Sodium chloride, NaCl	0.53	1.76	1.39
Combined water, H_2O+	...	0.08	nil	Potassium chloride, KCl	0.01	0.09	0.08
Moisture, H_2O-	0.15	0.97	1.17	Magnesium chloride, $MgCl_2$	0.08	nil	0.11
Silica, SiO_2	0.12	1.12	4.99[1]	Sulphur trioxide, SO_3	trace	0.13	0.15
Alumina, Al_2O_3 / Ferric oxide, Fe_2O_3 / Ferrous oxide, FeO	0.16	0.56	0.42	Total	100.10	100.06	100.38

[1] The specimen contained small veins lined with chalcedonic silica.

The deposits were not being regularly worked at the time of Feldtmann's visit. In 1917, 73 tons were shipped from Bulong, the export value of the mineral being estimated at slightly less than £4 per ton.

506. Manufacture of bricks and furnace-linings from dead-burned magnesite.

S. G. MCANALLY. U. S. 1,305,475, June 3, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 677 (1919).—Dead-burned magnesite bricks containing 15 to 18% lime, 6 to 6.5% silica, and 8 to 8.5% iron oxide and alumina are made by dead burning magnesite with lime, iron oxide, and silica, grinding the resultant product to a powder, mixing with water, molding into shapes, and drying and firing at a high temperature. This material is said to be highly refractory, inert to the corrosive action of slags, limestone, and molten metal, not to slake with water and to set or bind at a temperature slightly above the normal working of a steel furnace without the addition of other materials.

507. Method of manufacturing magnesite refractories.

R. D. PIKE. U. S. 1,312,871, Aug. 12, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 928 (1919).—The addition of 0.32%–0.75% ferromanganese and 1.5% to 2.5% of ferric oxide to California magnesite to improve its structure. The addition gives a hard, dense, strong magnesite refractory.

508. Magnesite in New Mexico.

ANON. *Min. Sci. Press*, p. 422 (1920); *Eng. Min. Jour.*, **110**, 673; *Jour. Amer. Ceram. Soc.*, **3**, 1001 (1920).—A small deposit of magnesite, having no commercial value, and lying 30 miles north of Lordsburg, N. Mex., was recently examined by R. W. Stone of the U.S.G.S.

509. Refractory substances.

G. I. DIMITRI. Brit. 142,512, May 1, 1920; *Jour. Amer. Ceram. Soc.*, **3**, 851 (1920).—Natural Mg silicates such as talc, steatite, Briancon chalk, are mixed in a powdered state with a flux consisting of natural or artificial multiple silicates such as feldspars mica pyroxene or the like, or with rocks containing them, as granite, gneiss, porphyry, pegmatite. The mixture is prepared moist or in powder form, dried, shaped, and fired at about 1450° to produce refractory and electric insulating articles.

510. Magnesite refractories.

R. M. HOWE AND J. S. MCDOWELL. *Jour. Amer. Ceram. Soc.*, **3**, 185 (1920).—H. and McD. give an exhaustive treatise on magnesite refractories with data under the

following headings; (1) historical note on magnesia refractories in steel making; (2) crude magnesite, its characteristics and occurrence; (3) manufacture of magnesite products; (4) properties of caustic, dead burned, and fused magnesia; (5) properties of magnesia brick; (6) microscopic studies. A large select bibliography is given.

511. Metalkose bricks.

N. E. MACCALLUM. *Blast Fur. Steel Plant*, **8**, 52–55 (1920).—Describes experiences with magnesite metalkose brick.

512. Magnesite in 1919.

W. C. PHALEN. *Eng. Min. Jour.*, **109**, 217–19 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 505 (1920).—A general review of the magnesite industry is given. Among the topics briefly treated are the following: Stocks on hand at end of the war, unsettled domestic industry in 1919, industry in the west, effect of car shortage on production, Canadian magnesite industry, tariff legislation, uses of magnesite, and quality of the domestic product.

513. Converting high-grade material in magnesite-lined converters.

H. C. ROBSON. *Bull. Inst. Min. Met.*, No. 194, 10 pp. (1920); *Jour. Amer. Ceram. Soc.*, **4**, 500 (1921).

514. A refractory material manufactured from mica.

ANON. *Rev. Mat. Constr. Trav. Pub.*, **136**, 15B (1921).—The waste mica from porcelain factories is mixed with clay or with clay and crushed quartz and fired to a temperature sufficiently high to fuse the mica. The resulting product is a good refractory and a good electrical insulator.

515. The magnesite works of the Austro-American Magnesite Company.

K. ENDELL. *Metall u. Erz*, **18**, 597–601 (1921); *Ceram. Abs.*, **1**, 105 (1922).—Describes the commercial process of making magnesite refractories.

516. Refractory article of magnesia and alumina.

R. C. PURDY, M. F. BEECHER, AND A. A. KLEIN. U. S. 1,394,442, Oct. 18, 1921; *Ceram. Abs.*, **1**, 183 (1922).—A bonded material suitable for lining furnaces or making refractory receptacles is prepared by mixing pre-shrunk granules of one of the ingredients MgO or Al_2O_3, with the other of these 2 ingredients in finely divided condition and heating the mixture to a temperature somewhat below the melting point of any eutectic of the MgO–Al_2O_3 system to effect bonding.

517. Basic refractory composition.

H. P. BASSETT. U. S. 1,360,355, Nov. 30; *Ceram. Abs.*, **1**, 108 (1922).—A basic refractory composition suitable for lining open-hearth furnaces or Bessemer converters is formed of magnesium limestone 100, Fe scale or oxide 1–2, NaCl 2 and SiO_2 2–10 parts, heated to a high temperature and prepared in granular form.

518. Manufacture of refractory and insulating products.

G. L. DIMITRI AND J. E. DELAUNAY. Can. 217,417, Apr. 4, 1922; *Ceram. Abs.*, **1**, 234 (1922).—A natural Mg silicate is mixed with other silicates; the mixture is compressed, dried, formed into blocks, and fired at about 1450° in a muffle furnace. The compression may take place in a vacuum.

519. Magnesite.

S. H. DOLBEAR. *Mineral Ind.*, **31**, 451–56 (1922); *Ceram. Abs.*, **3**, 100 (1924).—There was an increase of production of 32% in 1922. Imports were 3½ times those of 1921. Practically all domestic production came from California and was used in the chemical industries and for manufacturing of magnesite cement. Most of the imported material came from the Austrian mines. This article gives tables of imports and domestic production.

520. Refractory material.

W. A. FRANCE. Can. 219,609, June 13, 1922; *Ceram. Abs.*, **1**, 279 (1922).—A small amount of molten $MgCl_2$ is mixed with burned magnesite, the mixture is moistened, then molded and pressed into the desired shape and allowed to dry without firing.

521. Magnesite production in Austria.

ANON. *Brit. Clayworker*, **32**, 174 (1923); *Ceram. Abs.*, **2**, 281 (1923).—The Austria-American Magnesite Co.'s works at Radentheim in Carinthia. The deposit lies on a plateau at an altitude of 1700 m. From here magnesite is transported by aerial cable 9 km. long. Grading and selecting is unnecessary. It is calcined at 1600–1700°C. One of the rotary kilns is 50 m. long and has a diameter of 1.8 m., its output being 55 T. of calcined magnesite in 24 hrs. Another kiln is 100 m. long and has a diameter of 2.85 m., its output being 200 T. per day. The coal consumption is 30 to 40 % of the output tonnage and is introduced in the pulverized form. The calcined product analyzes between the following limits: MgO = 85–88 %, CaO = 1.5–2.5 %, Fe_2O_3 = 4–5 %, Al_2O_3 = 1–5 %, SiO_2 = 4–6 %. As the fumes are injurious to vegetation the spent gases are carefully purified before being released into the air. Attached to the works is a brick plant where calcined magnesite is mixed with 5–7 % water and pressed into brick with a pressure of 1000 kg. per sq. cm. They are then fired at 1500–1520°C in a furnace tunnel through which they are passed.

522. A new commercial refractory.

ANON. *Chem. Age*, **8**, 419; *Ceram. Abs.*, **2**, 160 (1923).—Electrically sintered magnesite. Composition used by Carborundum Co., Niagara Falls: 95 % MgO, and less than 1 % iron oxide. Melting point is 2600°C. Especially resistant at high temperature to iron or iron oxide.

523. Refractory material.

DYNAMIDON-WERK ENGELHORN & Co. GES. Brit. 221,799, Sept. 14, 1923; *Ceram. Abs.*, **4**, 136 (1925).—Fired magnesite or MgO containing little or no flux is finely ground, pressed, and sintered at 1500–1600°. The MgO may be hydrated before sintering and the sintered material is crushed and may be used as a mortar for making brick. Clay, starch, or tar may be added to facilitate molding and fired or hydrated magnesite 5–10 % may be added to the sintered material.

524. The specific heat of magnesite at high temperatures.

A. T. GREEN. *Trans. Ceram. Soc.* (Eng.), **22**, 393–97 (1923); *Ceram. Abs.*, **3**, 289 (1924).—A table of specific heats for magnesite from 100°C to 1100°C is given.

525. Magnesia refractory.

W. W. GREENWOOD. U. S. 1,461,444, June 12; *Ceram. Abs.*, **2**, 226 (1923).—A composition of matter comprising pre-shrunk magnesia grains forming the major portion of the total mass and a ceramic bond proportioned and constituted to unite the grains into a super-refractory body which will withstand drying and firing without detrimental shrinkage.

526. Report on the Manchurian magnesite.

K. HIRANO. *Jour. Jap. Ceram. Assn.*, **361**, 414–23 (1923); *Ceram. Abs.*, **2**, 52 (1923).—Color, appearance, specific gravity, chemical composition, and firing behaviors of 102 specimens of magnesites which were collected from all mine-lots possessed by the South-Manchurian R. R. Co. except the Mt. Kamba and Mt. Gyushin whose magnesites were reported by the author in April, 1919, are described in detail. The range of specific gravity is 2.76–3.01. They have following compositions: 0.20–30.28 % silica, 0–1.80 % alumina, 0.18–4.37 % ferric oxide, 0–24.12 % lime, 16.32–47.02 % magnesia, and 26.20–51.78 % loss on ignition.

527. Texture and heat conductivity of refractory stone.

M. JAKOB. *Z. Ver. deut. Ing.*, **67**, 126–27 (1923); *Ceram. Abs.*, **3**, 221 (1924); *C. A.*, **18**, 1372 (1924).—The differences reported by various observers in the heat conductivity of $MgCO_3$, some values differing 20 fold, can be explained by differences in crystalline texture. It should be possible, by suitable mixing and heat treatment, to control the heat conductivity and temperature coefficient of ceramic products. The conductivity can be increased by the addition of graphite.

528. Magnesite refractories.

J. S. MCDOWELL. *Jour. Amer. Ceram. Soc.*, **6**, 280–85 (1923).—A historical review and statement of industrial development of data is given.

529. Refractory material for furnaces.

C. A. SCHARSCHU. U. S. 1,444, 527, Feb. 6; *Ceram. Abs.*, **2**, 131 (1923).—A refractory composition is formed in part of a coherent mixture of crystallized MgO, calcined MgO of lower density and C, and in part of a subvitreous monolithic layer of MgO particles bound together by sublimed MgO. This layer has a mass of density of 3.5–3.6 and is so hard that it has metallic ring even at electric furnace temperatures and it undergoes no material expansion or contraction at temperatures up to 1800°.

530. Basic refractory and process of making same.

A. P. MEYER. U. S. 1,483,468, Feb. 12, 1924; *Ceram. Abs.*, **3**, 130 (1924).—As a new basic refractory, an aggregation of hard, dense, angular individually fired granules of uniform nature and standardized composition, such granules being composed of a basic magnesian refractory containing enough intimately distributed fluxing material to permit bonding at open-hearth furnace temperatures.

531. On the thermal changes of magnesite.

YOSHIAKI TADOKORO. Research Lab. of the Iron Works, Yawata, Japan, *Report* **4** [2], 58 (1924); *Ceram. Abs.*, **4**, 279 (1925).—Strength diminishes with dissociation and shows slight increase at 1300°C. Slight decreases in weight at 120° in white and 200° in blue magnesite, probably loss of water. Dissociation begins at 400° and ends at 850°, with maximum at 600°. White specimens expand gradually to 650°, contract gradually to 950° where $CaCO_3$ dissociates and the contraction is sudden. Contract 3.3% in length at 1300–1450° where crystallization of amorphous MgO occurs. Slight changes at 1450° may be due to crystallization of amorphous CaO. Blue magnesite has slight but sudden expansion at 350–450°, probably caused by combustion of organic matter. Thereafter it is the same as the white. Cooling curves show no transition points. Linear contractions at 1600° were 4.5% and 7.0% in the white, and 6.5% and 10% when cold. In the blue they were .5% and .2% at 1600 and 2.5% and 1.7% when cold. In blue magnesite endothermal change began at 513° and difference rate attained its maximum at 652°. The temperature difference began to decrease at 687°, its rate becoming maximum at 757°, and came to normal state at 800° to 1300°. In the white there was a slight endothermic change at 300–430° probably due to dissociation of organic matter. Heat absorption due to dissociation of $MgCO_3$ began at 520°, attaining its maximum at 630°. A weak absorption at 900–950° may be due to dissociation of $CaCO_3$. From 1000–1600°C the blue magnesite shows heat absorption at 1280–1320° and 1420–1480°, probably due to crystallization of amorphous MgO and CaO. Water absorption in both rapidly increases up to the heating temperature of 500°, reaches its maximum at 700,° and becomes zero at 1300°. Specific gravity decreases to about 900° and increases to approximately the original at 1700°. Thirty-six microphotographs shown.

532. The electrical conductivity of magnesia refractories at high temperatures.

J. T. BURT-GERRENS AND R. S. KERR. *Trans. Roy. Soc. Can.*, **19**, 27 (1925); *Ceram. Abs.*, **5**, 93 (1926).—The electrical conductivity of magnesite brick up to 1550°C is given.

533. Magnesite and dolomite.

P. B. NYE. *Indus. Australian and Min. Stand.*, **73**, 612 (1925); *Ceram. Abs.*, **4**, 252 (1925).—A large deposit of dolomite and magnesite, suitable in regard to quantity and probably to quality has been discovered in Tasmania. A more detailed examination is necessary before its commercial value can be determined.

534. Refractory material.

JAMES E. SHEAFFER. U. S. 1,525,328, Feb. 3, 1925; *Ceram. Abs.*, **4**, 108 (1925).—A refractory made from powdered calcined magnesite and lignin liquor.

535. Magnesite mining at Red Mountain, California.

G. J. YOUNG. *Eng. and Min. Jour.-Press*, **120**, 178–80 (1925); *Ceram. Abs.*, **4**, 347 (1925).—Serpentine is the prevailing rock from which magnesite is derived by alteration, in this region. The magnesite is hand picked, approximately 50% of the broken material being rejected. Shaft and rotary calciners are used. Two grades of calcined product are shipped, No. 1 white and No. 2 slightly colored. The magnesite is of high quality and suitable for plastic purposes.

DOLOMITE REFRACTORIES

536. A ready means of molding lime and making lime or basic brick and lining for furnaces, converters, etc.

RILEY. *Jour. Iron and Steel Inst.*, 144–49 (1879).—Dolomite brick were made of magnesian limestone, fluxed with silica, iron oxide, and alumina, which gave satisfactory service in Bessemer converters.

537. The removal of sulphur and phosphorus in the Bessemer and Siemens-Martin process of steel manufacture.

GEORGE T. SNELUS. *Jour. Iron and Steel Inst.*, 135–43 (1879).—The following quotation from this paper discloses its scope: "I therefore patented the use of lime and limestone, magnesian or otherwise in all the various forms in which it occurred to me it was prossible to use for the lining of all furnaces in which metals or oxides are melted or operated upon while fluid."

538. On the elimination of phosphorus.

SIDNEY G. THOMAS AND PERCY G. GILCHRIST. *Jour. Iron and Steel Inst.*, 120–29 (1879).—This paper records the introduction and establishment of the use of dolomitic refractories. Calcium and magnesian limestones fluxed with siliceous and argillaceous materials were shown to be satisfactory refractories for their new basic process of making steel.

539. A new basic lining for furnaces.

L. ERDMENGER. *Jour. Iron and Steel Inst.*, 342 (1881).—Portland cement as a refractory material.

540. A note on current dephosphorization practice.

SIDNEY G. THOMAS AND PERCY C. GILCHRIST. *Jour. Iron and Steel Inst.*, 407–23 (1881).—A résumé of the technical results obtained with dolomitic refractories since their introduction in 1879.

541. The use of basic furnace lining in the refining of copper.

ANON. *Compt. rend.*, **93**, 1148; *Jour. Iron and Steel Inst.*, 337 (1882).—A mixture of tar and shrunk lime as a refractory is described.

542. The basic lining of converters.

V. DE MATTEI. *Genie Civil*, June 1882; *Jour. Iron and Steel Inst.*, **7**, 85 (1882).—Describes a method of making dolomitic refractories and discusses the amounts of fluxes required.

543. The basic process in America.

ANON. *Bull. Amer. Iron and Steel Assn.*, May 16, 1883; *Jour. Iron and Steel Inst.*, 746 (1883).—Deals with the introduction of dolomite refractories in the steel industry in America.

544. Basic lining for converters.

ANON. *Eng. Min. Jour.*, **53**, 208.—Blocks of burnt magnesian limestone.

545. The manufacture of basic open-hearth steel.

J. H. DARBY. *Jour. Iron and Steel Inst.*, 78–111 (1889).—A refractory material consisting of dolomite and chrome is described.

546. Dolomite brick.

ANON. *Jour. Iron and Steel Inst.*, 854 (1903); *Stahl u. Eisen*, **22**, 1201–1202 (1903).—Methods of manufacture and service performance of dolomite brick.

547. Open-hearth furnace practice.

W. SCHDANOW. *Jour. Iron and Steel Inst.*, 657 (1910); *Stahl u. Eisen*, **29**, 1930–91.—A comparison of magnesite and dolomite in regard to slag corrosion.

548. A peculiar type of clay.

H. RIES. *Amer. Jour. Sci.*, **44**, 316–18 (1917).—The specimen examined was from western Texas. Microscopic examination showed it to consist almost entirely of small rhombs of varying size but averaging about 0.008 mm. in diameter. The quantity of very fine undeterminable clay particles was almost negligible. Chemical analysis showed the sample to contain 98.5% dolomite and 1.5% $Al_2O_3+Fe_2O_3$.

549. Refractory material and method of making it.

B. ENRIGHT. U. S. 1,319,056, Oct. 21, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 1023 (1919).—The objectionable impurity of silica in dolomite used as a basic refractory is eliminated by mixing the dolomite with from 3 to 4% iron ore, pulverizing the mixture and firing it in a rotary kiln at 2700 to 3000°F. The silica is thereby caused to combine with the calcium and magnesium and so rendered innocuous.

550. Sintered dolomite.

ANON. *Tonind. Ztg.*, **44**, 519 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 924 (1920).—A dolomite suitable for sintering contained 32–42% MgO, 0.73% $Fe_2O_3+Al_2O_3$, and 1.34–1.9% SiO_2. (The technical use of lime, Kosmann, p. 91, 1919.) Block describes a process for sintering dolomite in a cupola furnace. A description of furnace is given in *Tonind. Ztg.*, 1907, p. 659, also in 1910, No. 126, 1913, No. 107, p. 1397. A plant for making dolomite brick is described in 1902, p. 2006.

551. Refractories for bottom-connected electric furnaces.

F. W. BROOKE. *Iron Age*, **106**, 1316 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 944 (1921).—Successful operation of electric furnaces having a conductive bottom depends upon: correct application of the current, the use of good double-burned *dolomite* and a good

pitch or tar, and good operators. The transformer connected directly to the bottom is designed to carry a heavier current than that carried by each electrode, which necessitates the bottom transformer having such a kw.-amp. capacity and a secondary voltage that when the top electrodes carry equal currents there is a perfect balance on the primary side. These features insure carriage of all current given to the furnace, no electric trouble from the deep holes formed during melting, and long life of furnace linings. A good pitch consists of the residue from coal tar distillation up to 250°. Quick "coming on" of the conductivity is effected by designing the furnace and putting in the bottom in such a way that all the excess tar will quickly drain away.

552. Refractory material and process of making it.

T. SHEARD. U. S. 1,329,434, Feb. 3, 1920; *Jour. Amer. Ceram. Soc.*, **3**, 416 (1920). —The preparation of a refractory composition from dolomite by firing to the oxide and then eliminating more or less CaO by HCl or liquor from galvanizing pickling vats. $CaCl_2$ removed centrifugally and residue formed into bricks and fired to about 1500°C.

553. Notes on slag conditions in open hearth basic steel making practice.

J. E. WILSON. *Jour. Iron and Steel Inst.*, **1**, 265 (1920).—Data on the chemical changes that take place in the corrosion of dolomite refractories by basic slags.

554. Experiments in the use of dolomite refractories.

ANON. *Eng. Min. Jour.*, **111**, 586 (1921); *Jour. Amer. Ceram. Soc.*, **4**, 685 (1921). —An abstract of a recent number of the Reports of Investigations of the U. S. Bureau of Mines. The sources and quality of magnesite and dolomite raw materials are discussed. Magnesite brick will stand storage indefinitely without disintegration. Tests of trade dolomite brick showed that they started to disintegrate within a week to six months. Two methods of calcination tried by the Bureau of Mines have given dolomite brick which had not started to disintegrate at the end of a year. The uses of dolomite refractories are given.

555. Sintered dolomite.

ANON. *Tonind. Ztg.*, **53**, 492 (1921); *Ceram. Abs.*, **1**, 661 (1922).—Description of the dead burned product and amount of bond required. Concludes that for the Siemens-Martin steel furnace the best sintered dolomite contains 3 % Al_2O_3 and Fe_2O_3 and 2.5 % SiO_2.

556. The preparation of the dolomite-tar mixture in Thomas (basic converter) steel works.

MAX BACKHEUER. *Stahl u. Eisen*, **41**, 954 (1921); *Ceram. Abs.*, **1**, 39 (1922).—The chemical and physical properties of the dolomite have an important bearing on the life of the converter lining. Burnt dolomite with slight loss on ignition is best but the dolomite should not be sintered since this prevents the absorption of the tar. The mixture for the converter walls should contain 35–40 % powder, 30 % fine and 30 % coarse dolomite mixed with 8–10 % of tar. The powder, 30 % fine and 30 % coarse dolomite mixed with 8–10 % of tar. The converter bottoms are made from a mixture of 45–50 % powder, 25 % fine and 25 % coarse dolomite with about 12 % tar.

557. Basic refractory material.

H. P. BASSETT. U. S. 1,390,328, Sept. 13, 1921; *Ceram. Abs.*, **1**, 11 (1922).—The hereindescribed basic refractory material comprises double burned dolomite, an oxide of a metal of the iron group, an alkali metal compound, and a silicon compound.

558. Dolomite bricks.

C. H. BREERWOOD. U. S. 1,380,701, June 7, 1921; *Ceram. Abs.*, **1**, 67 (1922).—Dolomite containing a small amount of Fe is ground very fine, fired at a temperature

sufficiently high to vitrify or malgamate it, finely reground, compressed under high pressure, and fired to form a vitrified brick adapted for lining kilns or steel furnaces.

559. Sintering of dolomite.

F. I. *Tonind. Ztg.*, **45,** 442 (1921).—Dolomite containing 4% Al_2O_3, Fe_2O_3 can be sintered most easily. The raw dolomite is mixed with coke and the mixture calcined at 1100°–1280°C. The calcined material is crushed and used in the granular form for furnace linings. It is also made into brick with 5–8% tar as a binder and pressed when hot under a high pressure.

560. Dolomite bricks.

T. Hodson, J. Hodson, W. Hodson, and T. A. Hodson. Brit. 193,576, Dec. 17,1921; *Ceram. Abs.*, **3,** 103 (1924).—Refractory basic bricks, furnace linings, retorts, etc., areobtained by calcining dolomite, magnesite, or magnesian limestone, adding small quantities (about 15%) of igneous rocks, other than granites and syenites, and in some cases a little basic Fe ore, mixing with H_2O, molding, and firing at 2000°. Suitable igneous rocks are the peridotites (including diorite and gabbro), the dolerites, (including basalts), the serpentines, trachytes, and andesites, tachylytes, eurites, and rhyolites. If rocks of the last two classes are employed, or if the dolomite contains more than 1% of SiO_2 or 57% of $CaCO_3$, it is necessary to add 3% of basic iron ore, such as titanic iron ore, magnetite, hematite, or gothite.

561. Dolomite refractories.

C. A. Longbottom, F. L. Duffield, and W. J. Rees. Brit. 191,412, July 4, 1921; *Ceram. Abs.*, **3,** 131 (1924).—Refractory products composed of dolomite are sealed against hydration after firing by immersion in molten wax, tallow, dehydrated oils or fats, or similar substances. Clay and either Fe_2O_3 or slag may be added to the dolomite in the preferred proportions of 2–10% of Fe_2O_3 and 2–15% of clay; or 2–10% each of slag and clay. The mixture is molded into bricks and shrunk by heating to about 1500°.

562. Experiments in dead burning dolomite and magnesia.

H. G. Schurecht. *Jour. Amer. Ceram. Soc.*, **4,** 127–51 (1921); *C. A.*, **15,** 2344 (1921).—Experiments were made in attempts to dead burn dolomite and magnesite with various fluxes, open hearth slag, kaolin, flue dust, iron ore, and roll scale. The resistance of dolomite to slaking increased with finer grinding, varied with percentage of fluxes, and decreased with increase in firing temperature 14–16. Magnesite showed decreased slaking tendency with increased firing temperature.

563. Dolomite (Norway).

O. Holtedahl and O. Andersen. *Norges Geol. Undersokelse*, 102 (1922); *Ceram. Abs.*, **2,** 129 (1923).—Dolomite, pure and fine grained, occurs in N. Norway. Preliminary experiments on burning dolomite are described. Small charges of dolomite were heated electrically to observe the degree of sintering attained and the dusting due to impurities of silicates or quartz in the dolomite. Each example was examined under the microscope before and after the heating treatment; heating for 2–5 hours at about 1400°C did not produce any effective sintering of the varieties of pure dolomite. Dusting had no harmful effect in the samples examined. Structure and size of grain of the raw dolomite had no predominating influence on the corresponding properties of the burned product. The mixture of lime and magnesia forming the results of the burning was always very fine grained. A brief review is given of the more promising methods for utilization of dolomite as an industrial raw material. Among the methods mentioned is electric sintering and melting of dolomite experimented on by a Norwegian firm, Oslandske Stenexport Co. References are given to U. S. Bureau of Mines publica-

tions. It is briefly indicated which methods might be used in attempting the exploitation of dolomite in Norway; the most recommendable way seems to be to try one of the methods suggested for the separation of lime from dolomite possible in connection with electric sintering or melting of raw dolomite.

564. Basic refractory brick.

S. B. NEWBERRY. U. S. 1,400,087, Dec. 13; *Ceram. Abs.*, **1**, 142 (1922).—A mixture of lime 2.10 and argillaceous material 3.35 parts is calcined, the proportions of the resulting materials being such that the clinker formed will not disintegrate after prolonged heating or exposure to the air. A mixture of lime and clay or the like of greater fusibility is added to the clinker and the mixture is molded and fired as usual in making fire brick.

565. Dolomite for refractories.

ANON. *Metal Ind.* (London), **23**, 460 (1923); *Ceram. Abs.*, **3**, 45 (1924).—U. S. Bureau of Mines at Columbus, Ohio, used dolomite with an alumina-iron flux from 5–50%. The slaking and refractoriness were tested. The best mixture was selected and proper firing procedure determined. A composition was found which produces a strong non-slaking brick of high refractoriness.

566. Manufacture of refractory products from dolomite.

C. A. LONGBOTTOM AND F. L. DUFFIELD. U. S. 1,463,399, July 31, 1923; *Ceram. Abs.*, **3**, 131 (1924).—The herein-described process for the manufacture of refractory products from dolomite which consists in artificially mixing binding materials with the raw dolomite, shaping the products from the mixture, subjecting them to an intense shrinking heat, and finally dipping them in a medium having sealing properties.

567. Studies on the dolomite system. I. The nature of dolomite.

A. E. MITCHELL. *Jour. Chem. Soc.*, **133**, 1055–69 (1923); *Ceram. Abs.*, **2**, 225 (1923).—Dissociation pressures of calcite, magnesite, and dolomite are different and definite; that of calcite being least, of magnesite, greatest. It is concluded that the thermal dissociation of dolomite is represented by $CaCO_3$, $MgCO_3 \leftrightarrows CaO$, $MgO + 2CO_2$. The thermal dissociation of calcite follows the Nernst equation. The specific heats of magnesite and the solid decomposition product of dolomite are, respectively, 0.2033 and 0.2101 cal. at 15–20°. The heats of solution of dolomite and its solid decomposition product in HCl have been determined, and the heats of formation of the 2 substances from their elements calculated. It is yet impossible to decide whether dolomite is a singular point in a series of solid solutions or a compound.

568. Dolomite.

L. M. PARSONS. *Trans. Ceram. Soc.* (Eng.), **22**, 323–32 (1923); *Ceram. Abs.*, **3**, 289 (1924).—Dolomite (first described by Dolomieu in 1781) is the double carbonate of Ca and Mg and is distinct from the mixture known as magnesian limestones. It contains 45% $MgCO_3$. Dolomite rocks are grouped as primary or secondary. Primary dolomites are produced originally in the dolomite state, either chemical by evaporation of salt-lake waters (precipitated or proto-dolomites), or mechanically by sedimentation of the prototype. Secondary dolomites are formed by chemical alterations of limestones, the influences being usually dissolved Mg salts, but, in rarer cases heated vapors containing Mg composition. Secondary dolomite may be "contemporaneous" or "subsequent"; in the former type, limestone on the sea-floor is acted on by the Mg salts in solution before the limestone becomes hard; in the latter, ground waters containing Mg salts percolate through limestone which forms part of dry land. In many cases, the ground waters have affected a limestone here and there so that the dolomite is in veins,

streaks, and patches. Most commercial dolomites are of the contemporaneous class. P. gives examples of all these types as they occur in England.

569. Technical developments in dolomite refractories.

H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **6**, 278–85 (1923).—A brief statement is given of the technical work to date on dolomite refractories.

570. The utilization of dolomite for refractories.

G. A. BOLE. Bur. of Mines, *Rept. of Investigations*, No. 2627, p. 11 (1924); *C. A.*, **18**, 3262 (1924).—Results of tests made indicate that (1) by using the proper fluxes in proper amounts it is possible to dead burn dolomite when properly sized and under proper heat treatment to a grain that will not slake; (2) several binders for the ground grains give promise, especially dextrin and Na silicate; (3) it is possible to form wares by either the semi-dry or the slop method. Details and analyses are given.

571. The dead burning of dolomite. I.

J. T. ROBSON AND J. R. WITHROW. *Jour. Amer. Ceram. Soc.*, **7**, 61–73 (1924); *C. A.*, **18**, 890 (1924).—Conclusions. (1) Kaolin is a fairly effective flux for dead burning dolomite. (2) There are many compounds and eutectics which may form among CaO, MgO, Fe_2O_3, Al_2O_3, and SiO_2. (3) CaO may combine with Fe_2O_3 and act as a solvent for CaO as does Ca aluminate. (4) The presence of Fe_2O_3 is essential to dead burning MgO to the stable form, periclase. (5) CaO is rendered inactive to water by calcination in the presence of impurities—SiO_2 and silicates. (6) The more MgO present in a lime, the slower it will slake.

572. Ibid. II.

Jour. Amer. Ceram. Soc., **7**, 207–21 (1924); *C. A.*, **18**, 1887 (1924).—The most unstable mixtures are those relatively high in Fe_2O_3. Refractory or fusion tests show that Al_2O_3 decreases the deformation point of dolomite more than does Fe_2O_3 or SiO_2. With less than 10% of total flux the deformation point is above standard cone 32, which classifies the composition as No. 1 refractories.

573. Ibid. III., IV.

Jour. Amer. Ceram. Soc., **7**, 300–11, 397–410 (1924); *C. A.*, **18**, 3260 (1924).—(1) Several good compositions to give dead-burned granular dolomite were found. (2) Five per cent flux is not enough to produce dead burning. (3) Any one of 3 fluxes alone was not satisfactory. (4) Pure dolomite of different crystalline character can be dead burned. (5) With 5 or 10% fluxes, deformation point was above cone 32; with 15% at or below cone 20 if Al_2O_3 exceeded 6% and Fe_2O_3 were present. (6) Al_2O_3 had the greatest fluxing action, Fe_2O_3 next, and SiO_2 least. (7) Molasses (13 to 23% by weight) was used in molding.

574. Analysis of dolomite refractories used in Europe for patching open-hearth furnaces.

ANON. *Blast Fur. Steel Plant*, **13**, 491 (1925).

575. Manufacture of refractory bricks, blocks or the like, from dolomite or other materials or substances possessing plasticity at a high temperature.

ANON. Brit. Pat. 223,616; *Quarry and Surv. and Contractors' Jour.*, **30**, 205 (1925); *Ceram. Abs.*, **4**, 282 (1925).—The improved method consists in molding the dolomite under pressure at a high temperature and the resultant molded articles or material, after emerging from the molds, are annealed. It has been found, up to the present, that a temperature of 1500°C is most suitable for granulated sintered dolomite alone, or dolomite mixed with any known fluxing agents, for example, ferric oxide, clay, or basic slag. The annealing process is carried out by automatically conveying the resultant molded

article or material in an annealing or cooling chamber or tunnel, the cooling being a very gradual one.

576. Dolomite as a refractory material.

ANON. *S. African Jour. Sci.*; *Eng. Min. Jour.-Press.*, **120,** 177 (1925); *Ceram. Abs.*, **4,** 346 (1925).—Bureau of Mines results show that 90% dolomite and 10% flux is best mixture for use in the steel industry. This composition is found naturally in the dolomites of the Transvaal. The composition varied from 74 to 94% lime and magnesia. A dolomite containing 10% fluxes consisting of silica, iron oxide, alumina and manganese is now used in the Transvaal iron and steel furnace. For open hearth furnace the dolomite without calcination is crushed to a coarse powder and spread over the bed of the heated furnace in a bath of molten iron. For hearths in the electric furnace the dolomite is dead burned, ground to 4-mesh and mixed with melted tar.

577. The making of dolomite brick and a study of their properties. I.

A. I. ANDREWS, G. A. BOLE, AND J. R. WITHROW. *Jour. Amer. Ceram. Soc.*, **8,** 84–100 (1925); *C. A.*, **19,** 1039 (1925).—Discusses mixtures used in making dolomite brick. Discusses the properties of the finished product.

578. Ibid. II.

Jour. Amer. Ceram. Soc., **8,** 171–90 (1925); *C. A.*, **19,** 1480 (1925).—Gives mixtures and method of making good dolomite brick in the laboratory. Also physical properties of the fired brick.

579. Basic refractory material and method of making the same.

ARTHUR LEE BROWNE. U. S. 1,527,347, Feb. 24, 1925; *Ceram. Abs.*, **4,** 107 (1925).—A basic refractory material for use in lining furnace consisting of the product formed by heating a mixture of dolomitic limestone, 2.5% to 5% oxide of iron, and 1.5% to 2% feldspar, to a temperature above the melting point of feldspar.

580. Refractory and method of making the same.

K. P. MCELROY. U. S. 1,551,201, Aug. 25, 1925; *Ceram. Abs.*, **4,** 311 (1925).—In a basic refractory material granular fragments of shrunk, burnt dolomite exteriorly provided with a less refractory layer of dolomite material.

581. Synthetic refractory material.

JAMES F. MOLLEN AND WALTER W. PATNOE. U. S. 1,525,655, Feb. 10, 1925 *Ceram. Abs.*, **4,** 107 (1925).—A refractory material suitable for furnace linings and the like, consisting of the calcination product of raw dolomite admixed with a small percentage of argillaceous matter together with a small percentage of common salt, such material being in the form of heat-compacted masses of desired shape and size substantially clean and free from dust directly as made and having approximately the following percentage composition, *viz.*, lime and magnesia together 85, and argillaceous matter 14, the salt being substantially eliminated incidentally to calcination of the raw ingredients.

CHROME REFRACTORIES

582. On a neutral lining for metallurgical furnaces.

M. FERD GAUTIER. *Jour. Iron and Steel Inst.*, 151–62 (1886).—This paper introduces the use of chromite as a refractory lining for basic steel furnaces.

583. Chrome iron ore lining.

LUNDSTROM. *Jour. Iron and Steel Inst.*, 276 (1891).—Service performance of chromite in steel furnaces.

584. Chrome brick.

ANON. *Brit. Clayworker*, **28**, 178 (1918); *Jour. Amer. Ceram. Soc.*, **2**, 1020 (1919). —Chrome brick are neutral in character which gives them an advantage over silica clay and magnesite brick. The brick have a cold crushing strength of 1800–5800 lbs. per sq. in. Clay-bonded brick will stand a temperature of 1700°C while lime-bonded brick will withstand temperatures above 1850°C.

585. Disadvantages of chrome brick.

F. R. PAYNE. *Met. Chem. Eng.*, **18**, 20 (1918); *Trans. Ceram. Soc.* (Eng.), **18**, 16A (1919).—Chrome brick used in the walls of reverberatory furnaces for treatment to blister copper show little corrosion or slagging and do not crack. However, they absorb metal to a considerable extent and its recovery is a problem. The used brick are crushed and the large particles of metal taken out. The remainder is used for making new brick.

586. Chrome ore deposits in Asia Minor.

ANON. *Jour. Roy. Soc. Arts*, **68**, 564–67 (1919); *Jour. Amer. Ceram. Soc.*, **4**, 312 (1921).—The chrome producing districts of Turkish Asia Minor are classified in 4 zones; Brusia, Smyrna, Adana, and Konia. Brusia Province produces 10,000 to 15,000 tons of high grade (44–55 % Cr_2O_3) ore annually, Smyrna 7,000 to 15,000 tons (40–55 % ore), Adana 1,000 tons (50–51 % Cr_2O_3), and Konia 1,000 tons. Transportation and mining methods are primitive.

587. Tentative method for ultimate chemical analysis of chrome ores and chrome brick.

ANON. *Proc. A.S.T.M.*, **20**, I, 647–51 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 774 (1921). —*1. General method.* Dry the fine powder at 110° for not less than 1 hour. Cool in a desiccator. Fuse 0.5 grams of the sample with approximately 10 grams of fused $KHSO_4$ in a Pt crucible. The most refractory ores should be thoroughly fused in 1½–2 hours. Allow the crucible to cool in the air and dissolve the fusion in 200 cc. hot HCl (1 : 1), boiling until the solution acquires a clear green color. Evaporate to dryness on a water bath and bake at exactly 120° until free from HCl fumes. Moisten with hot HCl (1 : 1), evaporate and bake as before. Dissolve in 200 cc. hot dilute HCl and filter SiO_2. Ignite and weigh the SiO_2, determining the SiO_2 by treatment with HF and H_2SO_4. Any appreciable residue should be fused with $KHSO_4$ and added to the filtrate. Dilute the filtrate to 500 cc. and precipitate Fe, Al, Cr, and Ti with NH_4OH in very slight excess. Filter, dissolve in HCl, and reprecipitate. Again filter the combined hydroxides and dissolve in HNO_3. Evaporate in a casserole adding crystals of $KClO_3$ from time to time until the Cr is completely oxidized. Dilute with hot H_2O and again precipitate with NH_4OH, filtering as before. Repeat the oxidation 2 or 3 times until the filtrate shows no further traces of Cr. Combine the filtrates and evaporate to 500 cc. Add H_2SO_3 until the solution changes to a brilliant green color and heat to boiling. Add a very slight excess of NH_4OH, filter, wash, ignite, and weigh as Cr_2O_3. The hydroxides of Fe, Al, and Ti are ignited and weighed. Fuse the combined oxides with a small amount of $KHSO_4$, dissolve the fusion in dilute H_2SO_4, reduce with H_2S and titrate with $KMnO_4$. Determine the Ti colorimetrically and calculate the Al by difference. To the combined filtrates from the hydroxide precipitation add Br, allow to stand a few minutes and then add sufficient NH_4OH to precipitate the Mn. Boil, filter, ignite, and weigh as Mn_3O_4. From the filtrate precipitate the Ca with NH_4OH and $(NH_4)C_2O_4$ and determine in the usual way either by ignition to the oxide or by titrating with $KMnO_4$. Determine the Mg in the filtrate from the Ca precipitate in the usual way as $Mg_2P_2O_7$, and use the J. Lawrence Smith method for the determination of alkalis. *2. Rapid routine method.* Fuse 0.5 grams of the fine dry sample with 8–10 grams of Na_2O_2 in a Ni or porcelain crucible. Leach out with cold H_2O, boil 15 min.,

cool, and add 100 cc. H_2SO_4 (1 : 1). Cool, and titrate the Cr with ferrous solution and $KMnO_4$. To determine Si and Fe, fuse 0.5 grams of the sample in a Ni crucible, leach out with cold H_2O, acidify with HCl, and evaporate to dryness. Take up with 200 cc. of H_2O and add 10 cc. HCl. Filter SiO_2 and if necessary repeat the evaporation and filtration. Make the filtrate alkaline with NaOH and add 5 cc. Br. Digest ½ hr. on a steam bath. Filter $Fe(OH)_3$ on asbestos; dissolve, and reprecipitate. Filter again, dissolve in hot HCl, reduce with $SnCl_2$, and titrate with $KMnO_4$ in the usual way.

588. Chrome in 1919.

S. H. DOLBEAR. *Eng. Min. Jour.*, **109**, 171–72 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 501 (1920).—The domestic industry is reviewed in a superficial manner and brief references are made to some of the foreign sources of chrome.

589. Chrome bricks.

R. E. GRIFFITH. *Brick*, **61**, 180 (1922); *Trans. Ceram. Soc.* (Eng.), **22**, 24A (1923). —The hard ores containing 45–50% of chromic oxide, low iron, and well balanced proportions of silica, magnesia, and alumina are by far the most desirable and give the most satisfactory results.

590. Refractory containers for molten metals.

E. W. HALE. Can. 229,316, Mar. 6, 1923; *Ceram. Abs.*, **3**, 131 (1924).—The lining of a container for molten metals consists of bricks containing at least 30% Cr. The oxide film formed on the surface of the lining protects the lining from corrosion.

591. Chrome refractories.

J. S. MCDOWELL AND H. S. ROBERTSON. *Jour. Amer. Ceram. Soc.*, **5**, 865–87 (1922); *C. A.*, **17**, 455 (1923).—Discuss the history, mineralogy, physical properties, chemical properties, occurrence, deposits, production, and uses of chrome ore; the manufacture, properties, and uses of chrome brick. Under properties are discussed properties in general, crushing strength hot and cold, resistance to abrasion, thermal conductivity, electrical resistivity, effect of temperature changes, and chemical behavior. A bibliography is also given.

592. The marketing of chromite.

EDWARD SAMPSON. *Eng. Min. Jour.*, **115**, 356–58 (1922); *Ceram. Abs.*, **2**, 128 (1923).—Chromite is the only ore of chromium and its compounds. Theoretically, Cr_2O_3 68%, FeO 32%; Al_2O_3 and Fe_2O_3 may partly replace Cr_2O_3 and MgO and FeO. Little or no chromite is normally produced in U. S. New Caledonia, Rhodesia, India, main producers, Turkey in Asia, Russia and Greece less important. Refractories consumed 35% of chromite brought into U. S. in 1922. Chemicals 25% and ferro chrome 40%. Chromite for refractories should be low in silica. Analyses of representative ores given. Marketing, prices, production, and imports charted 1909–1922.

593. Refractory brick.

J. A. WRIGHT. Can. 215,847, Feb. 14, 1922; *Ceram. Abs.*, **1**, 210 (1922).—Refractory bricks are made from natural deposits of chromite and serpentine rock by crushing, agitating with slight moisture to distribute the serpentine particles evenly throughout the chromite, and then firing in a kiln.

594. Chrome refractories.

J. S. MCDOWELL. *Jour. Amer. Ceram. Soc.*, **6**, 277–78 (1923).—A historical sketch of development of the industry.

595. Chromite.

ANON. *Clay-Worker*, **82**, 431 (1924); *Ceram. Abs.*, **4**, 77 (1925).—Gives sources of chromite. In the manufacturing of chrome brick, the chromite is usually finely ground

in a ball mill, tempered in a wet pan, and dry pressed. They are fired at cones 18–20 and are slowly cooled. Chrome brick are neutral in character and are unattacked by iron oxide scale. The crushing strength and resistance to abrasion are low at high temperatures. They have poor resistance to spalling. Their fusion temperature ranges from 2050° to 2180°C.

596. Chrome refractories for the open hearth.

R. E. GRIFFITH. *Jour. Amer. Ceram. Soc.*, **7**, 690–98 (1924); *C. A.*, **18**, 3262 (1924). —Many failures of Cr ores are due to high refractoriness and the difficulty of bonding at the lower temperatures. Synthetic chrome cements, properly proportioned, are better than straight chrome ore for patching and for cementing work.

597. Fused ore of chromium oxide and method of making the same.

MINER L. HARTMANN. U. S. 1,524,030, Jan. 27, 1925; *Ceram: Abs.*, **4**, 108 (1925). —The process of producing a refractory article, comprising fusing chromium oxide ore and shaping the article from the fused ore.

SILICA

598. Coke-oven stone destruction and its causes.

E. SCHRIEBER. *Stahl u. Eisen*, **30**, 1839–44 (1910); *C. A.*, **5**, 1332 (1911).—Investigation into the rapid destruction of coke-oven walls lined with silica brick makes it evident that the destruction is due to the chemical action of the alkalis. These come within from the water or basic ash. Analysis of the melted and destroyed parts of brick showed a per cent of 4–5 times the original amount of alkalis. At the high temperature the NaCl and Na_2SO_4 are dissociated and unite with the SiO_2. Especially noticeable where the heat is about 1200–1300°, no action at 900–1000°. Increase of Al_2O_3 content adds greatly to its resistance to the attack of the alkalis, but such bricks are subject to greater twisting. In general the best results are obtained with SiO_2 brick strongly pressed and sharply fired.

599. Making refractory materials for furnace linings, retorts, etc.,

H. A. D. COLLINS. U. S. 782,252, Jan. 24, 1911; *C. A.*, **5**, 1176 (1911).—Made by mixing SiO_2 90–99 % and powdered water-glass 10–1 % with heat and moisture to form a plastic mass, molding while heated under pressure and immediately fired at a temperature of at least 1500°. A small amount of CaO or other alkaline compound may be added.

600. Fire brick for gas retorts.

ANON. *Brit. Clayworker*, **23**, 154–56 (1914); *Trans. Ceram. Soc.* (Eng.), **14**, 9A (1915).—Some questions and answers on silica retorts, as to materials used, and building up of the retorts, the expansion, cause of cracking, use with automatic stoking material, life of retorts, and cost of operation. Some tests of refractories under load were determined, and it was found that the melting point was materially lowered when the refractory is placed under pressure.

601. The bond in silica bricks.

W. J. REES. *Brick Pottery Trades Jour.*, **21**, 500; *Trans. Ceram. Soc.* (Eng.), **14**, 10A (1915).

602. Ganister production in 1916.

ANON. *Rock Products*, **20**, 33 (1917).—The U. S. Geological Survey reports the output of ganister in 1916 to be about 859,956 tons, valued at $529,805, about 62 cents a ton.

This was an increase of 50% in quantity, 58% in value, and 3 cents in average price compared with 1915. Ganister rock was quarried in Alabama, Colorado, Illinois, Maryland, Ohio, Pennsylvania, South Dakota, and Wisconsin. Pennsylvania and Wisconsin are the chief producing states. The former's output was 675,424 tons or 79% of the total; the latter's 137,577 tons. Blair and Huntingdon Counties furnished most of the ganister rock quarried in Pennsylvania, and quarries near Devil's Lake, Sauk Co., furnished most of that quarried in Wisconsin. Many manufacturers of silica brick or refractory products quarry their own stone.

603. The manufacture of SiO_2 brick.

H. LeChatelier and B. Bogitch. *Compt. rend.*, **165,** 742(1917); *Bull. Amer. Inst. Min. Eng.*, 1435–62(1918); *Trans. Ceram. Soc.* (Eng.), **18,** 122A(1917); *C. A.*, **12,** 2674(1918).—Five causes of failure in order of importance: (1) surface spalling, (2) surface melting, (3) flaking or shelling in the less intensively heated regions, (4) dislocation of the roof by excessive expansion, and (5) collapse of roof. Effect of physical properties and composition on melting point and strength.

604. Silica refractories.

J. S. McDowell. *Foundry Trade Jour.*, 487–88(1917); *Trans. Ceram. Soc.* (Eng.), **17,** 81A(1918).—An investigation of the effect of grinding on silica brick when fired and refired. The cross-breaking and crushing tests were used. Uniformity of strength decreases with repeated firing. Most uniform brick are those of the regular grind. The second firing increases the strength of the medium and fine grind. The effect of variations in grind is slight.

605. Tests made on silica brick from the Dunes works.

Anon. *Rev. Met.*, **15,** 487–509(1918); *C. A.*, **13,** 1251(1919).—Compositions, physical data. Results of tests on: (1) fineness of grain, (2) effect of percentage of water, and (3) variable CaO.

606. Silica brick.

H. LeChatelier. *Quarry*, **23,** 72(1918); *Trans. Ceram. Soc.* (Eng.), **19,** 8A(1920). —A good silica brick left in the flue of a furnace at 400–500°C will be found broken in several pieces after a time. Sudden rushes of heat in the furnace will melt the brick and weaken the arch. The admission of air must be regulated so as to keep the temperature within the narrow limits of 1650° to the softening point of the brick. Iron oxide and CaO (derived from the dust) in the brick eventually lower the fusing point.

607. Experiments on silica brick.

M. Philipon. *Rev. Met.*, **15,** 51(1918); *Jour. Amer. Ceram. Soc.*, **2,** 754–56(1919).—Four different materials having the following compositions were used:

	1	2	3	4
SiO_2	97.20	97.00	96.30	97.60
Al_2O_3	0.78	1.82	2.40	0.95
Fe_2O_3	0.37	0.60	0.40	0.52
CaO	0.90	0.00	0.28	0.00
MgO	0.00	0.00	0.00	0.00
Ignition loss	0.60	0.50	1.00	0.80
Fusion temp. °C	1770	1780	1790	1770

1. White quartz from the Central Plateau.
2. Normandy quartz.
3. Sandstone from Pas-de-Calais.
4. Amorphous silica from Allier.

The materials were ground and separated into portions of different size of grain, the average size of grain of each portion being used in interpreting the results. 1½% of CaO was used. Water was added and the mixtures ground wet for 10 minutes and molded into ordinary-sized brick. These were dried on iron plates at 100°C and fired to 1300°C, the conditions being kept alike in all the tests. The results obtained are shown in the following tables:

TABLE I

Showing Effect of Size of Grain on Compressive Strength of Brick Fired to 1300°C. Figures by Interpolation from Author's Fig. 2.

Diameter of grains in mm.	Nearest corresponding mesh of Tyler standard testing sieves	Compressive strength Kg. per sq. cm.		
		1	2	4
0.05	300	250	300	210
0.06		140	230	80
0.07	200	50	150	25
0.08		23	80	5
0.09		14	55	
0.10	150	8	37	
0.12		5	20	
0.14		3	10	
0.16			5	
0.18	80		4	

No mixtures of different sizes were used.

TABLE II

Showing Effect of Amount of CaO on Compressive Strength of Brick after firing to 1300°C. By Interpolation from Author's Fig. 5.

%CaO	Crushing Strength, kg. per sq. cm. No. 1	2	3
0	50	110	
0.5	172	208	147
1.0	278	270	220
1.5	310	290	253
2.0	304	287	263
2.5	262	252	257

TABLE III

Effect of Amount of Water on Strength of Brick of Material Passing 200-Mesh Sieve

% Water	Compressive strength after drying. Kg. per sq. cm.	Compressive strength after firing to 1300°C. Kg. per sq. cm.
15	12	180
16	13	195
17	15	190
18	15	220
19	17	250
20	19	265
21	20	270

TABLE IV

Effect of Amount of Lime on Fusion Temperature

%CaO	0	0.5	1.0	2.5
Quartz III.....	1790	1780	1750	1740
Quartz I.....	1770		1760	1730

TABLE V

Effect of Size of Grain and Amount of Lime upon Various Properties

		Compressive strength Kg. per sq. cm.	Per cent expansion	Porosity			Compressive strength Kg. per sq. cm.	Per cent expansion	Porosity
Quartz 1	A	270	1.2	18.0	Quartz 3	A	200	1.3	21.0
	B	285	1.4	18.6		B	228	1.5	19.8
	C	243	1.5	17.7		C	175	1.4	19.0
	D	194	1.6	16.2		D	165	1.5	18.2
Quartz 2	A	242	1.1	22.0	Quartz 4	A	194	1.4	20.5
	B	223	1.1	19.3		B	171	1.5	19.7
	C	225	1.2	18.5		C	155	1.6	17.8
	D	205	1.3	17.0		D	138	1.8	15.9

	Per cent passing 200-mesh	Per cent grains 2 to 8 mm	Per cent CaO
Series A.....	60	40	1.2
B.....	50	50	1.0
C.....	40	60	0.8
D.....	30	70	0.6

608. Fused silica; its properties and a few of its uses.

STEPHEN L. TYLER. *Trans. Amer. Inst. Chem. Eng.*, **11**, 189–202 (1918); *Jour. Amer. Ceram. Soc.*, **4**, 165 (1921).—The history of development of this manufacture is given. The use of fused SiO_2 in cascade concentrators for H_2SO_4 is discussed. It is not suitable for H_3PO_4. Prospective development in spark-plug insulators is discussed.

609. Silica refractories.

W. J. REES. *Jour. Birmingham. Met. Soc.*, **7**, 151 (1919); *Jour. Inst. Metals*, **23**, 601–603 (1920); *C. A.*, **16**, 4317 (1922).—The origin and uses of refractory materials high in SiO_2 are given. The manufacture of brick from silica rock is described in some detail. Color is no criterion for refractoriness. Texture of the brick is an important factor. Silica brick are generally superior to fire brick for a load at high temperature. A permanent expansion of 10–15% is not abnormal in bricks used at 1500–1600°.

610. Factors influencing the properties of silica bricks.

ALEXANDER SCOTT. *Iron Coal Trades Rev.*, **98**, 737 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 838 (1919).—Vein quartz of a fairly high degree of purity was made up into test pieces with 2½% additions of lime, magnesia, alumina, iron oxide, iron oxide with carbon, and titanic oxide, and binary and ternary mixtures of these. These were fired to cones 14, 16, and 19 in commercial kilns. The various properties of the resulting bodies were studied.

611. Study of transition points by dilatometric method.

PAUL BRAESCO. *Ann. de Phys.*, **14**, 5–75 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 161 (1921).—Contains data on the thermal dilatation of the silica minerals.

612. Comparative tests of machine made silica bricks.

W. EMERY AND L. BRADSHAW. *Gas. Jour.*, **150**, 577–79 (1920); *Gas World*, **72**, 61–62 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 80 (1920); *C. A.*, **14**, 2403 (1920).—Tests made from same Dinas mixture showed machine made brick superior to hand made in respect to mechanical strength, resistance to spalling and abrasion, and accuracy of shape.

	Machine made	Hand made
Refractoriness cone	33	33
Refractoriness under load	26	26
Reversible expansion (%)	1.2	1.2
After expansion	.355	.36
Porosity	25	25.1
Specific gravity	1.85	1.8
Crushing strength cold (lbs./sq. in.)	2270	1630
Spalling loss in weight (%)	36	56
Spalling loss in crushing strength (%)	8.51	35.5
Sandblast loss in weight (g)	106	143

613. A comparative study of American and German quartzite as raw materials for the silica brick industry.

K. ENDELL. *Jour. Amer. Ceram. Soc.*, **4**, 953–60 (1921).—(1) Properties determined. A chemical composition, cone fusion temperatures, microstructure in the raw state and after successive firings, and velocity in inversion on successive firings. (2) Comparative firing behaviors. After a single firing to 1435°C the German erratic block quartzites of the tertiary age show a much greater expansion than the American quartzites. Hessian quartzite resembles the American. (3) Advantages of the German quartzites. The use of the German erratic block quartzites for the manufacturing of silica brick of the highest quality is the more economical, both in preparation and firing costs, as compared with the American quartzites.

614. Silica bricks for coke ovens.

F. GRUBER. *Stahl u. Eisen; Iron and Coal Trades Rev.*, **102**, 232–33 (1921); *C. A.*, **15**, 1205 (1921).—A test of batteries of coke oven. The silica brick were found to be much more resistant to the gas and salts than the fire clay. Time of coking reduced and better material obtained.

615. Reversible thermal expansion of silica.

H. S. HOULDSWORTH AND J. W. COBB. *Coll. Guardian*, **122**, 1003 (1921); *Ceram. Abs.*, **1**, 141 (1922).—On firing, the quartz first undergoes a permanent linear expansion, with little or no decrease in density, but an increase in porosity. Further firing to cones 14–16 alters the expansion curve, the quartz being more or less completely changed to cristobalite. A determination of the true density of the powdered brick is the best guide to its expansion behavior.

616. The possibility of preparing high grade silica bricks from quartzite rock.

E. LUX. *Stahl u. Eisen*, **41**, 258–64 (1921); *Ceram. Abs.*, **1**, 67 (1922).—Good silica brick can be made from quartzite rock provided a sufficiently high firing temperature is used.

617. Silica brick for coke ovens.

A. H. MIDDLETON. *Coll. Guardian*, **121**, 1203–1204 (1921); *Ceram. Abs.*, **1**, 107 (1922); *C. A.*, **16**, 484 (1922).—Silica brick is not used as extensively in Great Britain for lining coke ovens as it is in U. S. This is a discussion of the present developments in the use of this material for ovens. See also *Gas World*, **75** [1946], 16–17 (1921); *Gas Jour.*, **156**, 630–31 (1921).

618. Silica bricks.

PEASE AND PARTNERS, LTD. AND J. WILSON. Brit. 193,999, Dec. 8, 1921; *Ceram. Abs.*, **3**, 102 (1924).—Small proportions of china clay and lime are added to Dinas stone, ganister, or other material used in making silica bricks. Preferred proportions are 96% of silica, 2½% of china clay, and 1½% of lime. The china clay and lime are suspended in the water with which the powdered silica is rendered plastic.

619. Silica brick for coke ovens.

SMITH, ESCOTWOOD, CARR, AND MELLOR. *Coll. Guardian*, **122**, 1273–74 (1921); *C. A.*, **16**, 1311 (1922).—Advantages of silica over clay brick for coke ovens are greater strength, greater resistance to the slagging action of salty and damp coals, and making possible the use of higher temperatures. Disadvantages are greater heat conductivity, expansion, and deposition of carbon. A decrease in the quantity of by-products is claimed by some.

620. The expansion of silica brick in coke ovens.

ANON. *Brick Pottery Trades Jour.*, **30**, 6 (1922); *Ceram. Abs.*, **2**, 16 (1923).—Silica brick used for coke ovens in England contain less than 84% SiO_2 on account of high expansion of high temperatures. For this reason brick which may be fired safely at 1200°C will spall when fired rapidly at 1400°. It has not been found practical to make a brick wholly of tridymite and the next best thing is to fire the brick to 1400°C to reduce the expansion to a minimum.

621. Report of work on the raw materials and the manufacture of silica bricks.

F. CELLERIER. *Rev. Mat. Constr. Trav. Pub.*, **106B**, No. 154 (1922); *Trans. Ceram. Soc.* (Eng.), **22**, 23A (1923).—A petrographic examination is necessary along with the other tests in order to have a true measure of the quality of the brick. Data and specifications in detail are given for silica brick.

622. The testing of silica brick.

K. H. ENDELL. *Jour. Amer. Ceram. Soc.*, **5**, 209–10 (1922); *C. A.*, **16**, 1843 (1922).—Specifications. Says load test for SiO_2 brick is unnecessary. A discussion on this paper is given in *Bull. Amer. Ceram. Soc.*, **1**, 180–84 (1922).

623. The influences of grind and burn on the characteristics of silica brick.

R. M. HOWE AND W. R. KERR. *Jour. Amer. Ceram. Soc.*, **5**, 164–69 (1922); *C. A.*, **16**, 1843 (1922).—Finer grinding increases strength only slightly. Time of grinding has no effect upon porosity. Firing temperature is the chief factor influencing final strength and permanent residual expansion. Cone 19, the highest temperature, gave the highest strength and lowest expansion. See discussion, *Bull. Amer. Ceram. Soc.*, **1**, 184–87 (1922).

624. Refractory silica materials of S. Wales, with special reference to the influence of texture.

W. R. R. JONES. *Trans. Ceram. Soc.* (Eng.), **21**, 358–93 (1922); *Ceram. Abs.*, **2**, 255 (1923).—Microscopical examination indicated that quartzites suitable for use in the manufacture of silica bricks should consist of angular grains set in a siliceous cement in optical continuity with the quartz grains, and should contain some chert or cryptocrystalline silica, but little non-siliceous matter. They should show a wave-like extinction of the quartz grains. The crushed silica rocks and sands were graded by sieving and by the elutriation of the material passing through a 30-mesh sieve. The results obtained gave further evidence of the similarity of the materials used in S. Wales for the manufacture of silica brick. Test-pieces molded with water from the raw materials and without the addition of any bonding material were heated to 1350° and their cold crushing strengths subsequently determined. It was seen that the finer the grade of the material the higher was the compressive strength of the test pieces. The drying shrinkage was small, while a further shrinkage of about 0.2% was found after firing to 1000°, but the brick began to show expansions after firing at 100°. The specific gravity of the brick decreased with successive firings, the rate of conversion of the quartz increasing with the fineness of the material.

625. Comparison of hot and cold modulus of rupture for silica brick.

E. N. McGee. *Jour. Amer. Ceram. Soc.*, **5**, 888–900 (1922); *Trans. Ceram. Soc.* (Eng.), **22**, 93A (1923); *Rev. universelle mines*, **17**, 36–37 (1923); *C. A.*, **17**, 2483 (1923). —Advantages of silica brick for coke ovens given. The cross-breaking strength of a brick at 1350° is approximately one third the strength at atmospheric temperature. Too rapid or erratic firing up to dull red heat will cause weakening of the structure or of the bond.

626. Refractory silica brick and process of manufacture.

O. Rebuffat. Italy, 1,420,284, June 20, 1922; *Ceram. Abs.*, **1**, 316 (1922).—The process of rapid conversion of quartz into its allotropic varieties of lower specific gravity by incorporating therein small quantities of the radicals of acids nonvolatile at high temperature and calcining the same and recovering the allotropic varieties of the quartz of lower specific gravity than quartz.

627. Refractories for coke-oven practice.

W. J. Rees. *Chem. Trade Jour.*, **70**, 326–27 (1922); *Ceram. Abs.*, **2**, 18 (1923); *C. A.*, **16**, 2598 (1922).—Assuming proper selection of the brick for oven construction the advantages of SiO_2 brick may be summed up as follows: (1) Resistance to corrosion where salty coals are coked. (2) The possibility of increased output due to higher thermal efficiency. (3) The greater durability, more particularly under high temperature coking conditions. The SiO_2 brick analyzed about 94–97% SiO_2 and 1.8–2.5% CaO.

628. Refractories for coke-oven construction.

W. J. Rees. *Brit. Clayworker*, **31**, 130 (1922); *Trans. Ceram. Soc.* (Eng.), **21**, 116A (1922).—The presence of salt causes rapid corrosion to both fireclay and semi-silica brick but does not corrode silica brick much. A test verified these statements. Silica should have a low porosity and only a small amount of unconverted quartz. Silica brick also gives increased output and greater durability (mechanical strength).

629. The influence of heat on the microscopic properties of silica in its different mineral forms.

J. T. Robson. *Jour. Amer. Ceram. Soc.*, **5**, 670–74 (1922).—A study is made of the effect of heat at cone 13 and cone 14 on the index of refraction of the four common mineral forms of silica used in the ceramic industries. These mineral forms are sand, quartz, chalcedony, and French flint. The effect of these mineral forms on the index of refraction of porcelain bodies fired to cone 13 and cone 14 is also given.

630. Rammed linings replace bricks.

Anon. *Brit. Clayworker*, **32**, 17 (1923); *C. A.*, **17**, 3080.—Rammed linings of ganister or silica rock are being used to replace fire brick. Almost pure SiO_2 rock is crushed to powder, mixed with about 2% CaO and then ground into a stiff paste with H_2O. Patching is done after every heat, and a re-lining is not necessary for 2 years or more.

631. The Derbyshire Silica Firebrick Company works at Frieden.

Anon. *Brit. Clayworker*, **32**, 113–14 (1923); *Ceram. Abs.*, **2**, 254 (1923).

632. The silica brick works of the Consett Iron Company.

Anon. *Coll. Guardian*, **126**, 1163–64 (1923); *Ceram. Abs.*, **3**, 102 (1924); *C. A.*, **18**, 452 (1924).—An illustrated description of the Consett Iron Company brickworks. The products contain approximately 30% tridymite and only a trace of unconverted quartz, insuring absence of permanent or after-expansion. Expansion is nearly complete

at approximately 600°, none occurs at 1000°–1400°, and above 1400° a slight contraction takes place. See also *Coll. Guardian*, **127**, 157 (1924); *Ceram. Abs.*, **3**, 317 (1924).

633. How to make good silica brick.

E. E. AYARS. *Brick and Clay Rec.*, **63**, 550 (1923); *Ceram. Abs.*, **3**, 74 (1924).—A discussion of each step in detail beginning with the selection of the raw material, throughout the manufacture, to the final inspection.

634. Process for manufacturing new and improved high refractory.

CHARLES J. CRAWFORD. U. S. 1,477,810, Dec. 18, 1923; *Ceram. Abs.*, **3**, 76 (1924).—A silica brick consisting of tridymite bonded with a clay of high alumina content. The herein described method of manufacturing a fixed volume high refractory substance which consists of firing a silica material in a kiln the atmosphere of which is charged with a gaseous catalyzer formed independently of the material being treated.

635. The use of refractory materials in gas works.

G. M. GILL. *Trans. Ceram. Soc.* (Eng.), **22**, 377–92 (1923); *Ceram. Abs.*, **2**, 199 (1923); *Ibid.*, **3**, 289 (1924); *Gas World*, **78**, 416–18; *Engineering*, **115**, 696–98 (1923); *C. A.*, **17**, 2494 (1923).—The temperature of carbonization in recent years has increased from 1280 to 1400°C in order to obtain a 50% increase in output and retorts which have a life of 1000 working days are now required to be more permanent. The best material, silica brick, often shows too much after-expansion and has to be built up instead of molded; it has also a tendency to spall. Fire clay shows too much after-contraction and a tendency to soften under load. G. suggests a semi-silica material containing 76–92% SiO_2 according to the position in setting and the purpose for which it is required. 75% of the material should have an expansion or contraction of not more than 1% at 1400°C under load, and the remaining 25% not more than 1% at 1280° under load. Combustion-chamber arches should be of 95% SiO_2.

636. Geology of the Baraboo ganister deposits.

W. O. HOTCHKISS. *Jour. Amer. Ceram. Soc.*, **6**, 1160–66 (1923).—This is a detailed description of the clays and quartzite of the Baraboo district with analytical data, map, and examples.

637. Technical developments in the field of silica refractories during the past twenty-five years.

E. N. MCGEE. *Jour. Amer. Ceram. Soc.*, **6**, 285–90 (1923).—Industrial history of production and use of silica brick is given.

638. Silica brickworks and coke ovens.

A. H. MIDDLETON. *Trans. Ceram. Soc.* (Eng.), **22**, 168–81 (1923); *Coll. Guardian*, **127**, 157 (1924); *Ceram. Abs.*, **3**, 317 (1924); *C. A.*, **18**, 1380 (1924).—Silica brickworks and coke-oven plant of the Consett Iron and Steel Co., Consett, England, are the best equipped works in the world. In building their Fell ovens, 3600 tons of silica brick were used. In the new ovens with a reduction of only 3 in. in the width they had reduced the coking time from 26 hrs. to 16 hrs. 20 min. without any increase in temperature. The yields of by-products were the same as in the old plants. The coking time could be reduced further by raising the temperatures and a reduction in coking time to 14½ or 15 hours. The plant has been in operation 14 weeks drawing 75 ovens per day.

639. The influence of some fluxes on the transformation of quartz.

N. PARRAVANO AND C. ROSELLI DEL TURCO. *Gaz. Chim. Ital.*, **53**, 249 (1923); *Trans. Ceram. Soc.* (Eng.), **23**, 2A (1924); *Ceram. Abs.*, **3**, 59 (1924).—Tests on the

fluxing action of Fe_2O_3, B_2O_3, CaO, and WO_3 in the transformation of quartz to tridymite were made. B_2O_3 gave the best results with Fe_2O_3 a close second.

640. Destruction of coke-oven walls.

W. PULFRICH. *Tonind. Ztg.*, **47**, 271–72 (1923); *C. A.*, **18**, 452 (1924); *Ceram. Abs.*, **2**, 198 (1923).—Spalling of SiO_2 brick after 1 year service caused by the transition of the quartz to tridymite in the mortar.

641. Tridymite and tridymite bricks.

O. REBUFFAT. *Atti congresso naz. chim. pura applicata*, 284–85 (1923); *Trans. Ceram. Soc.* (Eng.), **23**, 14–15 (1924); *Ceram. Abs.*, **3**, 288 (1924); *C. A.*, **18**, 3459 (1924).—A study was made of tridymite brick which had been made according to the catalytic process of R. Such bricks did not increase in volume when exposed for some hours to 1650°, and decreased in density only from 2.26 to 2.23–2.24 at 1700°. The latter slight increase in volume is due to a change from a crystalline to a vitreous state. The results of the experiments tend to exclude the idea of the formation of cristobalite above 1400° by transformation of tridymite, and even at lower temperatures the density of the product leads to the same conclusion. When the higher density and the complex way in which cristobalite loses and acquires birefringence are considered, it seems likely that it represents a state of maximum molecular condensation and therefore it is not necessary to assume the tridymite is transformed to cristobalite above 1450°. Microscopic examination was not of assistance in the work, nor could the determination of n by the method of Becke be successfully applied.

642. On the addition of chromium oxide to silica bricks.

STEN SANDLUND. *Jernkontorets Annaler* (Sweden), 45–52 (1923); *C. A.*, **19**, 566 (1923); *Ceram. Abs.*, **4**, 16 (1925).—S. tested a method for increasing the resistance of silica brick to the corrosive action of FeO-bearing slags by adding Cr_2O_3 to the brick. The composition of the refractories, slags, and the resultant melt are given. A protective coating of the highly refractory chromium spinel, $FeO.Cr_2O_3$, is supposed to be formed at the contact between the brick and the slag. An increase of Cr_2O_3 in the silica test pieces from 2 to 5% has only a small influence on their resistance to corrosion.

643. The Derbyshire Silica Firebrick Company's Works.

ANON. *Brit. Clayworker*, **33**, 325 (1924); *Ceram. Abs.*, **4**, 77 (1925).

644. Fire clay and silica brick as gas-house refractories.

A. F. GREAVES-WALKER. *Gas Age-Record*, **53**, 567–70 (1924); *Ceram. Abs.*, **3**, 269 (1924); *C. A.*, **18**, 1895 (1924).—Requirements for gas-house refractories listed, and characteristics of silica brick discussed from the view point of gas-house refractories.

645. Silica (New South Wales).

L. F. HARPER. *Geol. Surv. Bull.*, No. 10, 1924; *Ceram. Abs.*, **4**, 221 (1925).—Known deposits of material in New South Wales suitable for the manufacture of silica brick are 2 types, and although analyses of bricks made from each of the 2 types of deposits are practically the same, the reactions to firing are very different. Bricks made from the Ulladula deposits will not stand variations in temperature but they are said to be equal, if not superior, to any other silica brick for steel furnace works. The bricks made from the Marrangoroo quartzite are most suitable for furnaces at glass works, gas works, and other places where brick is subjected to variations in temperature. It appears that New South Wales has silica suitable for manufacturing of high grade silica bricks adapted to all requirements.

646. Factors affecting the resistance of silica refractories to abrasion.

F. A. HARVEY AND E. N. MCGEE. *Jour. Amer. Ceram. Soc.*, **7**, 895–906 (1924); *C. A.*, **19**, 712 (1925).—Resistance to abrasion is tested by grinding a groove in the surface of the refractory by means of a SiC wheel. Porosity and degree of firing are the factors affecting resistance to abrasion. Porosity is determined by the grind, the quality of ganister, the % CaO, and the workmanship.

647. The influence of phosphoric acid and phosphates on the rate of inversion of quartz in silica-brick manufacture.

W. HUGILL AND W. J. REES. *Trans. Ceram. Soc.* (Eng.), **23**, 204–206 (1924); *C. A.*, **19**, 2869 (1925).—No effect on the rate of inversion of quartz with phosphate additions could be found by specific gravity determinations.

648. Effect of repeated firing on the structure and properties of lime-bonded bricks.

W. HUGILL AND W. J. REES. *Gas Jour. Suppl.*, 24–27, July 9, 1924; *C. A.*, **19**, 3358 (1925).—Brick made from Sheffield ganister with lime bond were tested after firing repeatedly (up to 11 firings) in a works kiln. Greater part of inversion took place in the first firing but there was a steady decrease in the amount of quartz present and the porosity up to the seventh firing, with very little volume change after the first firing. Crushing strength increased up to the seventh firing, toughness increased gradually after the sixth firing, and transverse strength increased gradually up to the fifth firing. The chemical analysis was not affected by repeated firing. The per cent of tridymite increased with the number of firings and after the eleventh firing most of the silica had inverted to tridymite.

649. The true specific gravity and after-expansion of lime-bonded silica brick.

W. J. REES. *Jour. Soc. Chem. Ind.*, **43**, 986 (1924); *Ceram. Abs.*, **3**, 350 (1924); *Trans. Ceram. Soc.* (Eng.), **24**, 66 (1925); *Ceram. Abs.*, **4**, 311 (1925).—Data are given in a graph and table for 40 bricks from Great Britain and France. There is a close relation for brick containing 1–3 % lime, between powder density and the extent of quartz conversion. There is a close relation for brick of fine and medium texture, but not for brick containing fragments of ¼ inch or more in diameter between powder density and after-expansion as determined by the after-expansion test. The powder density may, therefore, be used as an indication of the permanent volume change which is likely to occur during use. The grading of raw material has greater influence on the rate of quartz conversion than variation in the source of the raw material itself.

650. The storage of silica refractories.

W. J. REES. *Jour. Soc. Chem. Ind.*, **43**, 986 (1924); *Ceram. Abs.*, **3**, 350 (1924).—Silica brick which had been kept in the open for 6 months spalled badly in use, while new brick of the same make, texture, and specific gravity were satisfactory. The good brick had a cold crushing strength of 3000 lbs. per sq. in., while the stored brick had a strength of only 2200 lbs. per sq. in. It is found that loss in strength by exposure is in part due to a slight loosening of the bond due to hydration and solution in water, as well as to physical effect of frequent wetting and drying. These tests showed little or no distinction between coarse- and fine-textured brick, but in both cases the brick fired at higher temperatures were more resistant to the action of the water.

651. The grading of silica brick.

P. B. ROBINSON AND W. J. REES. *Trans. Ceram. Soc.* (Eng.), **23**, 1–11 (1924); *Ceram. Abs.*, **3**, 288 (1924); *C. A.*, **18**, 3459 (1924).—Silica brick, both green and fired, are examined to determine the important points in preparing mechanically strong bricks. As raw material, a hard, fine-grained ganister crushing into higher angular

fragments is desired. Optimum grinding results in 40% or more passing 90-mesh, 40% retained on 30-mesh, and the largest particles being 6–7 mm. in diameter. The firing temperature should be at least cone 20.

652. Testing silica brick.

E. STEINHOFF. *Stahl u. Eisen*, **44**, 1277–83 (1924); *Ceram. Abs.*, **4**, 166 (1925); *C. A.*, **19**, 3574 (1925).—Method of testing at Research Institute of the Dortmunder Union. The tests employed include a complete analysis, determination of melting point, true and apparent specific gravity, porosity, crushing strength at high temperatures, permanent expansion after prolonged heating, and percentage transformation of quartzite into cristobalite and tridymite; the microstructure and macrostructure are also examined. The limiting values for good brick are given for these tests. Photomicrographs are included to show the characteristic changes that take place in the microstructure after various periods of firing.

653. Notes on comparative test of quicklimes for silica brick manufacture.

L. J. TROSTEL. *Jour. Amer. Ceram. Soc.*, **7**, 452–54 (1924).—In attempting to evaluate lime for control purposes in the manufacture of silica brick, it was found that the most consistent results are obtained by using a figure based on the *total* calcium oxide as compared with the A.S.T.M. *available* calcium oxide content. In addition, the particular test used serves as a practical basis for the comparison of the numerous quicklimes offered the silica brick manufacturer by lime dealers.

654. European silica refractories.

S. S. COLE. *Jour. Amer. Ceram. Soc.*, **8**, 55–58 (1925); *C. A.*, **19**, 1038 (1925).—European ganisters were found to be quite similar to American, but brick made in Europe were not well bonded, were underfired, and low in fusion point. Only 2 out of 10 were comparable with good American grades.

655. Welsh brick industry.

J. HORTON. *Iron Trade Rev.*, **76**, 1520 (1925); *Ceram. Abs.*, **4**, 252 (1925).—Silica brick produced in S. Wales approximates 36 million annually. Districts producing silica brick in S. Wales include Kidwelly, Penwyllt, Hirwaun, Dowlais, Templeton, Llandebie, Brynamman, and Black Mountain. Of these Kidwelly is by far the most important, having the largest kilns in Great Britain. A short description of the brick-making process in that district is given.

656. The changes which take place in silica brick during their use in open-hearth furnaces.

W. J. REES. *Jour. Amer. Ceram. Soc.*, **8**, 40–42 (1925); *C. A.*, **19**, 1039 (1925).—The photograph of a vertical section of an old brick from an acid open hearth is shown and 6 photomicrographs ranging from hot to cold end show clearly the changes which have taken place. With highly converted, well-fired brick, durability may be increased by greater structural stability of the roof. Analyses of various zones are given.

657. The true specific gravity and after-expansion of lime-bonded silica bricks.

W. J. REES. *Trans. Ceram. Soc.* (Eng.), **24**, 66 (1925); *Ceram. Abs.*, **4**, 311 (1925).—Forty bricks were studied. Where lime content is between 1 and 3% there is sufficiently close relation for practical purpose between time, specific gravity, and degree of quartz inversion.

658. Silica brick and its manufacture.

H. SCHILLING. *Chem. Ztg.*, **49**, 6–7 (1925); *Ceram. Abs.*, **4**, 135 (1925); *C. A.*, **19**, 1038 (1925).—The refractories of a silica brick depend upon the network of tridymite crystals formed in firing to cone 15. Too coarse a structure in the quartzite causes

difficulties of solution in the flux (CaO) and crystallizing out as tridymite. The CaO plays a double rôle: (1) it acts as a flux, forming the matrix from which the pseudo-hexagonal tridymite crystals form, and (2) the Ca silicate acts as a binder. The MgO content of the fired CaO should not exceed 5% because the consequent increase in viscosity hinders the formation and crystal of tridymite.

659. The manufacture of silica brick.

H. SCHILLING. *Chem. Ztg.*, **49**, 508(1925); *Ceram. Abs.*, **4**, 135(1925); *C. A.*, **19**, 2731(1925).—For a given temperature the time required for firing silica brick is determined by the size of the particles and the structure of the quartzite used, *e.g.*, the smaller the particles the finer the structure, and the quicker the firing. This is altered by the presence of fluxes, such as CaO. To obtain a good product, slow cooling without excess of cold air, is necessary, thus allowing for crystallization with maximum stability. Finished brick must be preserved from moisture and freezing. Places where they may be used to advantage are mentioned.

660. Manufacture of silica bricks.

J. WILSON. U. S. 1,534,199, April 21; *Ceram. Abs.*, **4**, 168(1925).—The hereindescribed method of manufacturing highly refractory brick, which consists in intimately mixing china clay and lime each in a finely divided condition with natural siliceous stone also in a finely divided condition, the percentage of china clay being of the order of about 2.5% and that of the lime about 1.5% and forming the mixture into brick.

SILICON CARBIDE

661. Silfrax, a new silicon carbide.

F. J. TONE. *Sprech.*, **48**, 323(1915); *Trans. Ceram. Soc.* (Eng.), **16**, 91A(1917).—Silfrax has about 91–93% of silicon carbide, the rest being silica, free carbon, iron, and alumina. The crystal known as Carborundum is practically infusible, and its electrical conductivity increases as the temperature.

662. A new material for crucibles.

ANON. *Brit. Clayworker*, **29**, 204(1920); *Jour. Amer. Ceram. Soc.*, **4**, 167(1921).—The new bodies are made by adding bituminous or oil shale to clay. Other material containing volatile carbon which is decomposed upon heating may be used. Such a mixture is embedded in oil shale or coke to maintain reducing conditions and baked at 700–800°C. If the product is then fired to 1600°C it becomes hard and resistant to acids resembling Carborundum and may be ground and used as an abrasive. Biscuit ware may be saturated with liquid hydrocarbons and fired under reducing conditions so as to produce a similar product. The material differs from plumbago crucibles, carbon bricks, etc., inasmuch as the clay is saturated with minute particles of carbon. These particles may be sealed in the clay by firing until the necessary degree of vitrification has been reached, and by this means they may be completely protected from being fired away. This latter is a serious defect in some articles manufactured from carbonaceous matter and clay.

663. Refractory composition.

BUFFALO REFRACTORY CORPORATION. Brit. 176,436, Nov. 2, 1920; *Ceram. Abs.*, **1**, 254(1922).—A refractory composition comprizes Si carbide, flake or crystalline graphite, a flux, and a carbonizing binder, such as tar or molasses. As fluxes, clay, salts, such as borax, metallic or non-metallic oxides, or sulphides may be used. The mixture is molded in the usual manner and baked at about 1000°. Suitable proportions of the in-

gredients are 68 pts. of Si carbide, 25 pts. of graphite, and 7 pts. of flux, or of flux and binder. The composition is suitable for making heat-resisting articles such as crucibles, fire bricks, retorts, muffles, furnace cores, tubes, combustion boats, pyrometer tubes, furnace linings, and heat-resisting cements.

664. Carborundum coating for fire brick.

P. M. GREMPE. *Brit. Clayworker*, **29**, 113 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 850 (1920).—It has been found that with a sufficient coating, the firebrick need not be so refractory. 75% corundum and 25% water-glass makes a good coating. If the refractory is basic, 85% Carborundum and 15% water-glass may be used. Material dried for 24 hours and then heated up slowly. The coating becomes fired in the brick and leaves a glassy coating which protects the brick. Very resistant to temperature changes.

665. New German refractory product.

ANON. *Chem. Met. Eng.*, **24**, 1070 (1921); *Jour. Amer. Ceram. Soc.*, **4**, 943 (1921). —A coating composed of 75% Carborundum and 25% sodium silicate is painted on to fire bricks. The layer is about one-fiftieth of an inch thick and fuses to a glassy veneer which is said to be remarkably resistant to mechanical injury and the chemical action of flames. It has been used successfully as a lining for gas retorts.

666. Carborundum refractories in heat-treating furnaces.

M. L. HARTMANN. *Trans. Amer. Soc. Steel Treating*, **1**, 601–603 (1921); *Ceram. Abs.* **1**, 40 (1922).—In addition to superior resistance at high temperatures, the elimination of extensive repairs compensates for a higher initial cost when Carborundum is used.

667. Refractory material.

M. L. HARTMANN. U. S. 1,376,091, Apr. 26; *Ceram. Abs.*, **1**, 68 (1922).—A refractory material is formed of Carborundum with Zr silicate and Al silicate as bonding materials.

668. Refractory ceramic ware.

J. A. JEFFERY. U. S. 1,438,599, Dec. 12, 1922; *Ceram. Abs.*, **2**, 132 (1923).—A refractory material adapted for furnace linings or saggers is formed from a raw batch comprising a granular refractory material such as Si carbide and Edgar's plastic kaolin or a clay of like character.

669. Carborundum brick.

M. F. PETERS. *Jour. Amer. Ceram. Soc.*, **5**, 181–208 (1922); *C. A.*, **16**, 1863 (1922).—Specifications and properties given.

670. Refractory composition.

C. A. WHITE. Can. 225,123, Oct. 24, 1922; *Ceram. Abs.*, **2**, 53 (1923).—A non-recrystallized refractory material contains SiC, crystalline graphite, and a carbonizing binder. A flux such as borax, or sand and borax may be used to form a protective coating around the particles of the composition.

671. Non-recrystallized refractory material.

WILLIAM A. FARISH. U. S. 1,458,913, June 12, 1923; *Ceram. Abs.*, **2**, 226 (1923).—A non-crystallized refractory material for heat-resisting articles comprising silicon carbide, crystalline graphite, a carbonizing binder, and sand.

672. The history of the development of silicon-carbide refractories.

C. F. GEIGER. *Jour. Amer. Ceram. Soc.*, **6**, 301–306 (1923).—G. gives the history and status to date of use of SiC in refractories.

673. Refractory composition.

JOHN L. OHMAN. U. S. 1,458,724, June 12; *Ceram. Abs.*, **2**, 226 (1923).—A refractory composition for heat-resisting articles, comprising silicon carbide and crystalline alumina, and crystalline graphite.

674. Refractory article.

EDWIN B. FORSE. U. S. 1,472,945, Nov. 6, 1924; *Ceram. Abs.*, **3**, 15 (1924).—A refractory article containing silicon-carbide grains having its surface pores filled with finely divided silicon carbide.

675. The thermal conductivity of Carborundum refractories.

M. L. HARTMANN AND O. B. WESTMONT. *Trans. Amer. Electrochem. Soc.*, **46** (reprint); *C. A.*, **18**, 3263 (1924).—Thermal conductivity measurements up to 1350°C of SiC refractory materials have been made, the water calorimeter method being used. Data were obtained on furnace walls such as those commonly used in practice and results are believed to be accurate to within about 1%; conductivity measurements were made on 7 SiC single walls and on 8 SiC fireclay composite walls. The relation of the thermal conductivity to the temperature, chemical composition, and porosity was investigated, as well as the magnitude of the surface and joint effects. The conductivity of SiC refractories varied with the quantity of heat energy transmitted through the wall. Tables are given showing the coefficients of thermal conductivity and heat flow through various types of walls with temperature of 1500° in the combustion chamber.

676. Refractory composition.

JOHN L. OHMAN. U. S. 1,479,107, Jan. 1, 1924; *Ceram. Abs.*, **3**, 75 (1924).—A refractory composition for heat-resisting articles, comprising silicon carbide and fused silicon oxide, and crystalline graphite.

677. Composition for refractory wicks.

CARL BUBERL. U. S. 1,546,616, July 21, 1925; *Ceram. Abs.*, **4**, 281 (1925).—A refractory wick composition of the class described including carbide of silicon and a binder.

678. Refractory article and method of making the same.

CHARLES F. GEIGER. U. S. 1,546,833, July 21, 1925; *Ceram. Abs.*, **4**, 281 (1925).—A refractory article containing silicon carbide, alumina, and a binder produced by the reaction of said silicon carbide and alumina.

679. The thermal conductivity of Carborundum refractories.

M. L. HARTMANN AND O. B. WESTMONT. *Jour. Amer. Ceram. Soc.*, **8**, 259–95 (1925); *C. A.*, **19**, 1934 (1925).—Extensive investigations are reported on the thermal conductivity of SiC materials and of furnace walls where either SiC alone or SiC and fire brick are used. The conductivity of SiC increased with increase in the quantity of heat energy transmitted through the wall.

680. Trace heat lost through walls.

M. L. HARTMANN AND O. B. WESTMONT. *Foundry*, **53**, 219–20 (1925); *Ceram. Abs.*, **4**, 166 (1925); *Iron Trade Rev.*, **76**, 22 (1925); *C. A.*, **19**, 1934 (1925).—The thermal conductivity of Carborundum brick was measured by the method of Dudley. Conclusions: Thermal conductivity of pure Carborundum is constant for temperatures from 650–1350°C. The thermal conductivity of ceramically bonded Carborundum increases with increased temperature. With increased per cent of fireclay bond in the brick the thermal conductivity decreases and the temperature gradient through a wall

increases. The thermal conductivity of a fire clay is inversely proportional to the porosity.

SILICA—FUSED GLASS

681. Apparatus for and method of making vitreous silica.

PHILIP K. DEVERS. U. S. 1,536,821, May 5, 1925; *Ceram. Abs.*, **4**, 196 (1925).—The method of making vitreous silica which consists in fusing silica in an enclosed space while maintaining a vacuum in said space and thereupon compressing the fusion at a pressure high enough to substantially eliminate bubbles.

682. Quartz glass and silica ware.

J. B. KERSHAW. *Ind. Chemist*, **1**, 208 (1925); *Ceram. Abs.*, **4**, 252 (1925).—History of fused quartz ware with reference to oxyhydrogen flame. Electric resistance furnace made possible the blowing of complicated ware.

683. Quartz working.

LEVI B. MILLER. U. S. 1,537,036, May 5, 1925; *Ceram. Abs.*, **4**, 196 (1925).—An apparatus for preparing fused or vitreous silica comprising the combination of a refractory container, one part of which has a greater diameter than the adjoining part and having a tapered throat connecting said parts, means for heating said container, and means for evacuating the space within said container. The method of preparing fused or vitreous silica, which consists in heating crystalline silica to a temperature of plasticity, subjecting said plastic silica to advancing constrictive pressure to eliminate cavities in said silica, and causing said silica to congeal while substantially preserving the cross-section thereof.

684. Process of making vitreous silica.

L. B. MILLER. U. S. 1,541,584, June 9, 1925; *Ceram. Abs.*, **4**, 222 (1925).—The method of producing clear vitreous silica or quartz glass which consists in heating quartz in the crystal state to a fusing temperature in a vacuum while mechanically supporting said quartz to prevent displacement of particles resulting from the cracking of said quartz when heated to a temperature of about 550°C.

685. The mechanical, thermal, and optical properties of fused silica.

ELIHU THOMSON. *Jour. Frank. Inst.*, **200**, 313–26 (1925); *C. A.*, **19**, 3574 (1925); *Ceram. Abs.*, **4**, 166 (1925).—Clear fused silica can now be made in large masses reasonably free from bubbles by melting in a vacuum furnace and subjecting the fused mass to high pressure during cooling. At 1750° SiO_2 begins to sub-lime rapidly. It has no melting point. Fused silica is like glass, hard, brittle, but more elastic and more transparent to ultra-violet and infra-red light as well as to the visible spectra. Its coefficient of expansion is low. It is non-hygroscopic and is a good electrical insulator. Slow cooling or holding too long at about 1200° will cause crystallization and loss of its unique properties.

686. Process of shaping fused silica.

E. THOMSON AND H. L. WATSON. U. S. 1,546,266, July 14; *Ceram. Abs.*, **4**, 253 (1925).—The process of making shaped articles having the properties of fused silica, which consists in filling a mold with a mass of particles of substantially pure crystalline silica and heating the mass throughout to a temperature sufficiently high to convert said silica to the vitreous state, causing expansion, and to cause coalescence of the particles, and shrinkage counteracting said expansion.

GRAPHITE

687. Graphite ore-deposits in Norbergs Bergslag.

GUSTAV T. LINDROTH. *Geol. För. Förh.*, **40**, 27–76 (1918); *Ceram. Abs.*, **1**, 37 (1922).—The history and production of the graphite deposits are reviewed, and their geology and petrography described in detail.

688. Fusibility of graphite ash and its influence on the refractoriness of bond clay.

M. C. BOOZE. *Jour. Amer. Ceram. Soc.*, **2**, 65–68 (1919).—Fusibility of ash from different grades of Alabama, Pennsylvania, New York, and Ceylon graphites was determined alone and mixed with clay. Very little relation between the softening point of the ash and that of the ash and clay mixtures was found. Ash from graphite has very little effect at brass foundry heats.

689. Some properties of bond clays for graphite crucibles.

M. C. BOOZE. *Jour. Amer. Ceram. Soc.*, **2**, 461–76 (1919); *C. A.*, **13**, 1136 (1919).—No single clay satisfied, to a high degree, all requirements. A mixture is best. A large amount of data regarding drying and firing behavior are tabulated.

690. The effect of electrolytes on the properties of graphite crucible bodies.

H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **2**, 443–50 (1919).—NaOH decreased working properties and strength of crucibles made of Dorset clay. HCl improved the Dorset clay crucibles. Opposite results were obtained with Mississippi clay.

691. Behavior under brass foundry practice of crucibles containing Ceylon, Canadian, and Alabama graphites.

R. T. STULL. *Jour. Amer. Ceram. Soc.*, **2**, 208–26 (1919).—Four series of crucibles were made by Vesuvius Crucible Company and tested in two brass foundries. Comparative results are given on Canadian, Alabama, and Ceylon graphites.

692. Effect of variable pressure and tar content on the briquetting of Alabama graphite.

R. T. STULL AND H. G. SCHURECHT. *Jour. Amer. Ceram. Soc.*, **2**, 391–99 (1919).—Description is given of method used to modify the Alabama graphite to produce granular form similar to that possessed by Ceylon graphite. Tested in service, crucibles of Alabama graphite unaltered were better than either Ceylon or briquetted Alabama.

693. Structure of graphite in relationship to crucible making.

R. THIESSEN. *Jour. Amer. Ceram. Soc.*, **2**, 508–42 (1919).—Thirty-one makes of crucibles were examined. Structure of the graphite and internal structure of the crucible were found to be important. Description of structure is given in great detail of Alabama, Pennsylvania, Canada, Madagascar, and Ceylon graphites. Structure of several English, Japanese, and American makes of crucibles as revealed by this cross-section under high magnification are described and summarized. The effect of graphite characteristics is compared.

694. Refractory.

F. J. TONE. U. S. 1,303,993, May 20, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 589 (1919).—This invention relates to refractory articles such as crucibles. The composition consists of graphite 40 parts, sintered magnesia 40 parts. Such a mixture is said to be easy to mold and work in the plastic state and after firing has a body which is very refractory, less oxidizable than graphite, of superior strength, of high conductivity, and great durability.

695. Graphite.

ANON. Dept. of Mines, S. Australia, *Mining Rev.*, **31**, 18, 52–6 (1920); *Jour. Amer. Ceram. Soc.*, **4**, 424 (1921).—A bonus is offered on marketable graphite produced

from any mine in S. Australia and sold prior to June 30, 1922. Development work is being continued by the Uley Graphite Syndicate. It is stated that there are 5000 tons of 11% ore blocked out and 10,000 tons of "probable" ore.

696. Properties of American bond clays and their uses in graphite crucibles and glass pots.

A. V. BLEININGER. Bur. Stand., *Tech. Paper*, No. 144 (1920); *C. A.*, **14**, 1202 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 328 (1920).

697. Graphite in Quebec, Canada.

H. P. H. BRUMMELL. *Eng. Min. Jour.*, **109**, 548–50 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 504 (1920).—Graphite is of widespread occurrence in Quebec, especially in Argenteuil, Labelle, Wright, and Pontiac counties where in the Grenville or upper part of the Laurentian series of rocks it occurs as disseminations, in masses, and in veins, the first named type of occurrence being the most important. The Quebec and Alabama graphite may be briefly compared as follows: (1) The Buckingham ore is Archaean in age while the Alabama material is Carboniferous. (2) Genetically, Buckingham graphite is inorganic or elemental. The Alabama graphite is organic and due to alteration of coaly or carbonaceous material contained in the sandstones prior to metamorphism. (3) In Quebec near the eruptives there is an enrichment of graphite while in the Alabama deposits an increase in muscovite occurs without appreciable change in the graphite content. (4) Alabama ore consists almost entirely of soft weathered ore; the Buckingham material is usually tough and hard. (5) Mineralogically they are similar, affording "flake graphite." The gangue in the Alabama ore, however, consists almost entirely of very friable quartz with a small amount of sillimanite (?), occasionally mica (either biotite or muscovite), cyanite, and tourmaline. The Buckingham material is accompanied by some quartz together with such common minerals as orthoclase, pyroxene, hornblende, sillimanite and occasionally mica (usually biotite), zircon, tourmaline, chondrodite, and pyrite. (6) Buckingham graphite is a coarser flake with higher specific gravity than that of Alabama and is in greater favor with crucible manufacturers. The Quebec graphite has a higher specific gravity than Ceylon graphite and in its heat-resisting qualities is practically the equal of the Ceylon material. Methods of concentration are considered and tables are included which show: specific gravity and refractory values of both domestic and foreign graphite; analyses of graphite from various North American districts and from Ceylon; grade of Buckingham deposits; screen tests on Quebec and Alabama materials.

698. Refractory compositions.

BUFFALO REFRACTORY CORPORATION. Brit. 176,437, Nov. 2, 1920; *Ceram. Abs.*, **1**, 254 (1922).—A refractory composition for making heat-resisting articles, such as crucibles, comprises a refractory electric-furnace product such as fused alumina or silica, flake or crystallized graphite, a flux, and a carbonizing binder such as tar or molasses. As fluxes, clay, salts such as borax, metallic or non-metallic oxides, or sulphides may be used. The mixture is molded in the usual manner and baked at about 1000°. Suitable proportions of the ingredients are 60 pts. of the electric-furnace product, 20 pts. of graphite, 12 pts. of binder, and 8 pts. of flux.

699. The fusibility of mixtures of graphite ash and bond clays.

R. N. LONG. *Jour. Amer. Ceram. Soc.*, **3** [8], 626–33 (1920).—The ash from Alabama graphite has a higher fusion point than the Ceylon ash and is less active as a flux in bond clay-ash mixtures. No eutectic was found between ash and clay. The fluxing action of the ash on the bond clay indicates that graphite with higher ash than at present might

be used without greatly affecting refractoriness. While increasing the ash does lower the refractoriness in proportion to the addition, still it does not destroy the advantage that one clay may originally have over another.

700. Refractory material.

JOHN L. OHMAN. U. S. 1,356,939, Oct. 26, 1920; *Jour. Amer. Ceram. Soc.*, **3**, 1004 (1920).—A non-recrystallized refractory material for heat-resisting articles comprising silicon carbide and crystalline graphite.

701. Graphite industry in Alabama in 1919.

W. F. PROUTY. *Eng. Min. Jour.*, **109**, 228 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 505 (1920).—Crippling of the industry due to removal of import restrictions on graphite is briefly discussed.

702. The separation of mineral matter from natural flake graphite.

W. C. RATLIFF AND J. D. DAVIS. *Chem. Met. Eng.*, **23**, 1027–28 (1920); *Ceram. Abs.*, **1**, 107 (1922).—Experiments show that while graphite, flake or amorphous, may be cleaned by agitation with oil and water, light volatile liquids such as C_6H_6 and CCl_4 are even better. The agglomerates formed with the volatile liquids are less viscous and the mineral matter is separated with less agitation than in cases where heavy oil has been used. Fineness had a direct bearing upon the effectiveness of the cleaning.

703. Graphite.

HUGH S. SPENCE. Can. Dept. of Mines, Mines Branch, Rept. No. 511, pp. 202 and LVI plates. Ottawa, 1920; *Jour. Amer. Ceram. Soc.*, **4**, 432 (1921).—This report is a general treatise on the subject of graphite with special reference to the Canadian deposits, mining and milling methods. Chaps. I, II, and III deal with the history, origin, composition, and economic importance of graphite. Chap. IV is devoted to graphite in Canada and gives individual descriptions of the various deposits including numerous maps. Chap. V covers the field of the concentration and refining of graphite, showing numerous flow sheets and diagrams of machinery from mills in the United States and Canada. Chap. VI disposes of artificial graphite while Chap. VII deals with the various uses of graphite. In Chap. VIII statistics of Canadian graphite production are given. Chap. IX is a discussion of foreign graphite deposits. The last chapter (X) is devoted to a discussion of the methods used in the analysis of graphite and is followed by a bibliography and index. At the end are a number of plates illustrating raw and manufactured graphite, graphite mines, and mills.

704. Crucible graphite.

Staff Article. *Chem. Met. Eng.*, **22**, 220 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 331 (1920).—Graphite for making crucibles should be of the crystalline variety and should have a high degree of purity. Most makers of crucibles prefer to use Ceylon graphite either alone or mixed with varying proportions of American flake, usually not exceeding 25% of the mixture. The more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of domestic graphite and hence require proportionately less clay as a binder. It is possible, however, to use domestic flake graphite alone with success. The graphitic carbon contents of No. 1 flake should be no less than 85%. Graphitic carbon is the carbon remaining after the dried sample has been fired for 3 minutes at 800°C. Screen analyses for No. 1 flake recommended are: Over 35-(standard) mesh, 3%; over 65-(standard) mesh, 50%; over 100-(standard) mesh, 100%. Although flake carrying 85% of graphitic carbon can be readily produced, the cost of a product containing 90% of graphitic carbon is very greatly increased. A sample of Ceylon graphite prepared for

crucible use contained 85.06% of graphitic carbon. In purity, therefore, the American graphite compares favorably with that from Ceylon. The past ten years has seen rapid increase in the manufacture of electric furnace steel, while the production of crucible steel has remained stationary. Recent developments in the electric furnace as applied to non-ferrous alloys also give promise of a rapid decrease in the use of crucibles.

705. Method of making clay and graphite crucibles.

J. H. L. DEBATS. U. S. 1,374,910, April 19, 1921; *Jour. Amer. Ceram. Soc.*, **4**, 866(1921).—The method of making crucibles or pots containing clay, which consists in mixing metal of the aluminum-magnesium group in a finely divided form with the material from which the crucible or pot is formed, and molding the same, whereby the crucibles or pots may be fired shortly after molding.

706. A study of some bond-clay mixtures.

D. H. FULLER. *Jour. Amer. Ceram. Soc.*, **4**, 902–15(1921).—In order to determine whether as good results could be obtained from mixtures of American clays as from the grossalmerode clay in glass pot bodies, two American ball clays were combined in various proportions with two siliceous American bond clays and compared with the grossalmerode clay in bodies containing 50% grog. Physical properties and resistance to glass batch corrosion were determined. It was not found possible to duplicate the physical properties, especially the low water of plasticity and low drying shrinkage of the grossalmerode body but several of the bodies gave better results as regards resistance to corrosion than the one containing the grossalmerode clay. In general it was concluded that it is possible by blending American clays to produce a body equal or superior to the grossalmerode body. More thorough heat treatment of pots or tank blocks in the arches and greater uniformity in temperature during the firing is required.

707. The question of the liquefaction of carbon.

SIEGMAR MÜNCH. *Z. Elektrochem.*, **27**, 267–68(1921); *Ceram. Abs.*, **1**, 40(1923).—It has been found that graphite becomes plastic before reaching its melting point. With sufficiently high amperage small graphite rods can be melted through and welded together again. A description is given of an apparatus for melting large quantities of C.

708. Graphite crucible.

HIROSUKE NAKAMURA, KOZO NAKAMURA, AND HIKOSHIMA RUTSUBO KABUSHIKI KAISHA. Japan, 40,310, Oct. 18, 1921; *Ceram. Abs.*, **2**, 162(1923).—The wall of the crucible forms V-shaped layers; it is manufactured by the machine described in 39,334. Owing to the special construction of the wall, it is resistant to changes of temperature and is very durable.

709. Graphite in Siberia.

ANON. *Raw Materials Rev.* (London), **1**, 155(1922); *Ceram. Abs.*, **1**, 316(1922).—As the result of various hydrographical and geological expeditions which recently investigated parts of Siberia, deposits of graphite have been found on the River Kureiki, a tributary of the Yenisei. These are estimated to contain at least 200,000,000 roods, or enough to satisfy the requirements of the world for several decades. Deposits of graphite have also been noted along the River Podkamennoi Tunguske, together with extensive measures of coal and cupreous nickel ores.

710. The nature of graphite and amorphous carbon.

GENSHICHI ASAHARA. *Sci. Papers Inst. Phys. Chem. Research*, **1**, 23–29(1922); *Jap. Jour. Chem.*, **1**, 35–41(1922); *Ceram. Abs.*, **2**, 99(1923).—The essential identity of graphite and amorphous C has been established by the *X-ray analysis of 34 different forms of C* from different sources. They were ground into fine powder and pressed to

layers of about 1 mm. thickness. These were fixed in front of a small window of a wooden box containing a photographic plate and placed in a lead camera. The interference figure of the material was recorded on the plate as concentric rings, the plate cutting the mantles of cones of the diffracted rays. Six of these cameras were arranged conically, with the vertex in the source of X-rays facing the X-ray bulb in a shielded box. The interference figures thus obtained constitute an unbroken series, gradually altering from those with 6 comparatively sharp concentric rings of intensity maxima (Type I) to those with an indistinct halo of distributed intensity (Type III). Those whose intensity maxima are not sharply defined but broadened ill-defined bands (Type II) lie between the two extremes. Certain forms of graphite, such as Ceylon and Korean graphites, etc., gave figures with radiant streaks (Type IV), the intensity maxima being common to graphites appearing intact. The streaks may be attributed to the fact that these graphites are only ground along their flat cleavage faces and the incident rays fall chiefly and almost perpendicularly on their cleavage faces. The angles corresponding to the 6 concentric rings, which the diffracted rays make with the incident rays, are approximately 14°, 18° 50′, 22° 20′, 25° 40′, 31°, and 36° 30′, respectively. The natural and artificial graphites, however finely they may be powdered, possess a crystalline structure, as they plainly show sharply defined interference rings. Amorphous C also gives interference figures, but no distinct maxima are observed owing to the distributed intensity. Their estimated maxima are however invariably at about 14° and 23°. Carbons produced by the decomposition of certain gases or vapors, such as CO C_2H_2, or CS_2, or Fe_3C and coal, gave no sign of definite crystalline form, but they gave definite interference figures which establish their crystalline nature. The word "amorphous" must, therefore, be replaced by "extremely minutely crystalline."

711. Graphite in Canada.

V. L. EARDLEY-WILMOT. *Can. Inst. Min. Met. Trans.*, **26**, 124 (1922); *Ceram. Abs.*, **1**, 314 (1922).—For commercial purposes, it is convenient to distinguish three varieties of graphite: crystalline, flake, and amorphous. Flake graphite occurs disseminated through the containing rock, whereas the crystalline forms true veins of more or less compact graphite. Amorphous graphite approaches coal in its physical characters, and is often found in contact with coal seams, shales, and slates. Graphite mining in Canada is confined to the provinces of Ontario and Quebec. E.-W. describes finishing and polishing, and flotation systems. Samples of Canadian graphite were submitted to all known crucible makers, but the general verdict was that although from the chemical standpoint Canadian graphites are as good as, or even better than the Ceylon graphite, they are inferior in physical characters. Re-floating in the Callow cells, followed by careful tabling and screening, has produced an 80-mesh, 87 to 90% concentrate, distinctly more angular, and denser than ordinary "finished" products. These samples have been submitted to crucible makers who reported this "natural" flake as good in every way as the best Ceylon graphite, and that it could be used in the crucible industry. Graphite mills and operations are described.

712. Graphite crucible.

RYUTARO KONISHI. Japan 41,935, Mar. 8, 1922; *Ceram. Abs.*, **3**, 102 (1924).—The resistance to oxidation and to heat of a graphite crucible is increased by coating the outside first with a mixture of 70 parts of Carborundum, 30 parts of a special porcelain clay and 30 parts of H_2O, and then with a mixture of 70 parts of a glaze (*e.g.*, made of 45 parts of feldspar, 18 parts of CaO, 10 parts of clay and 27 parts of SiO_2), 30 parts of Carborundum, and 100 parts of H_2O.

713. Madagascar graphite.

A. D. LUMB. *Bull. Imp. Inst.*, **20**, 61–68 (1922); *Ceram. Abs.*, **3**, 266 (1924).—Production of graphite in Madagascar began in 1907 with an output of 8 T. and increased to 35,000 T. in 1917, but has since fallen off considerably owing to post-war depression. It is of the flake variety and occurs in schists and gneisses in the older crystalline rocks, which extend over two thirds of the island. About 60% is considered of crucible grade. The mines are worked entirely by natives with European supervision for the larger enterprises. The separation of the pure graphite from the gangue is a rather difficult matter principally owing to the presence of mica, which is of nearly the same specific gravity as graphite and occurs in the same flaky form. In the early stages of the industry the method of treatment was very primitive, the process consisting in washing the material in a wooden trough, drying in the sun, panning, and sifting in a hand-sieve. Recent practice makes use either of a dry method, or a wet method, or a combination of the two, and a final concentration by oil flotation. This last treatment ensures a satisfactory separation of the mica and silica from the refined product. The Ceylon and Madagascar deposits are the most important in the world. Although the Ceylon is slightly superior in grade, the Madagascar can be mined much more cheaply and so can be sold at a much lower price.

714. Graphite.

B. L. MILLER. *Mineral Ind.*, **31**, 347–53 (1922); *Ceram. Abs.*, **3**, 100 (1924).—The graphite industry was almost stagnant in 1922. Wartime stocks have not been exhausted. Prices were lower than in 1922. A British patent contains new features. Natural graphite is purified from silica, alumina, pyrite, and mica by intimate mixing with coal, charcoal, or coke. The mixture is electrically heated to approximately 2200°C. The coal unites with impurities which are volatilized and collected. Silica is used for filtering or polishing powder, the SO_2 for manufacturing H_2SO_4, and metallic oxides for metallic purposes.

715. Bavarian graphite.

EUGEN RISHKEVICH. *Chem. Ztg.*, **46**, 1013–16, 1035–36 (1922); *Ceram. Abs.*, **2**, 100 (1923).—The graphite occurs in gneiss, replacing mica and associated with pyrite. It varies from 12 to 40%, usually 20 to 25%, C content, that under 12% not being worth mining. The ore comes in lenses, and mining is expensive. Crushing, sizing, and wet concentration, followed by fine grinding and concentration give a concentrate of 65% C, which can be raised to 80–90% by dewatering. Tests are described indicating the superiority of Bavarian graphite in electric conductivity, heat conductivity, resistance to combustion, etc., when compared with other kinds.

716. Refractory composition.

C. A. WHITE. Can. 225,124, Oct. 24, 1922; *Ceram. Abs.*, **2**, 53 (1923).—A refractory material contains a chemically inert refractory material, crystalline graphite, and a carbonizing binder such as tar or pitch. A flux such as borax or sand and borax may also be used to form a protective coating for the particles of the material.

717. Graphite, 1919–1921.

ANON. *Imp. Min. Res. Bur.*, 16 pp. (1923); *Ceram. Abs.*, **3**, 198 (1924).—The world's production of graphite, imports and exports for United Kingdom, Canada, Ceylon, India, Australia, France, Germany, Italy, Sweden, Madagascar, U. S., and Japan, are given in this statistical report, with prices and bibliography.

718. Some properties of graphite.

R. M. BURNS AND G. A. HULETT. *Jour. Amer. Chem. Soc.*, **45**, 572–78 (1923); *Ceram. Abs.*, **2**, 161 (1923).—The densities of various graphites were determined by

the liquid immersion method. The density of pure graphite is about 2.20, and that of Acheson graphite about 2.30. The density of C produced by the explosion of graphitic acid indicates that it is probably graphite. Completion of the "drift" or increase in weight during immersion in the liquid was hastened by pressure, and the tendency to drift was largely destroyed by compression by the determination of density.

719. Standardization of crucible sizes.

C. H. ROHRBACH. *Bull. Amer. Ceram. Soc.*, **2**, 240–42 (1923).—Adopted standard sizes and capacities are given.

720. Graphites for brass melting crucibles.

R. T. STULL AND L. E. GEYER. *Metal Ind.* (London), **23**, 466 (1923); *Metal, Ind.* (N. Y.), **21**, 477–78 (1923); *Ceram. Abs.*, **3**, 46 (1924); (Abs., U. S. Bur. Mines. *Rept.*, **25**, 42 (1923)).—Tests on bond clays had previously indicated that Missouri pot clay and Illinois kaolin were better than Klingenberg clay. Tests were next made to determine the value of American graphites for crucible making as compared with foreign ones. Missouri pot clay was used, and crucibles were made up with graphites from various domestic sources, and with Canadian, Ceylon, and Madagascar graphites. These crucibles were then tested in brass melting practice, and record kept of the failures. The most frequent cause of failure was pinholing, which usually developed at, or below, the slag line. Cracking was also a prominent cause of failure. The crucibles made of domestic graphite compared well with those made of the foreign.

721. Refractory articles.

H. WADE. Brit. 19,626 (1923); *Ceram. Abs.*, **4**, 253 (1925).—Hollow refractory containers are made from a composition containing graphite in excess of 15% and a ceramic bond also in excess of 15%, and are fired at a temperature exceeding 2000°F to vitrify the bond. According to an example, 15–65 parts of graphite, 15–50 parts of clay, and 5–15 parts of siliceous material are mixed and fired until the bond is vitrified (at least 2000°F). Other refractory materials, as alumina, silicon-carbide, zirconia, may be employed in addition. Fluxes, such as dolomite, or magnesite, may be added, and on firing produce a glaze on the articles.

722. Graphites for brass melting crucibles.

ANON. *Metal Ind.* (N. Y.), **22**, 59 (1924); *Ceram. Abs.*, **3**, 101 (1924).—Discussion of report from Bureau of Mines recommending American graphites. Based on interview with Jonathan Bartley. Gives compositions of alloys used and results of tests by R. T. Stull and L. E. Geyer, denoting that Alabama graphite bonded with American clays gave superior service. Sharp disagreement with this conclusion by two crucible manufacturers led to investigation of research work done by Bureau. Results were obtained only up to 13.1 heats per crucible when a crucible should give from 30–40 heats before being considered commercial. It was found that materials were assembled in 1918 and crucibles were not ready till December of that year. After the Armistice no effort was made to hasten work and the last of the crucibles were not tested till fall of 1922. During at least part of the period from 1918–22 good Ceylon or Madagascar graphite could not be obtained and the Alabama graphite was therefore tested against very low grades. Thus, the Bureau results are hardly conclusive and the use of American bond clays is more a matter of individual preference and local conditions. (See abstract above.)

723. Refractory article and method of making same.

C. J. BROCKBANK. U. S. 1,483,507, Feb. 12, 1924; *Ceram. Abs.*, **3**, 130 (1924).—A dense, hard, refractory, graphitic article of manufacture having a body bond and a

continuous glaze of non-ceramic material and of the same coefficient of expansion and other physical characteristics.

724. Refractory article and method of making the same.

C. J. BROCKBANK. U. S. 1,503,150, July 29, 1924; *Ceram. Abs.*, **3**, 290 (1924).—A refractory article of graphite and clay vitrified in an atmosphere of hydrocarbon gas and characterized by relatively increased hardness at high temperature and relatively increased refractory properties.

725. Graphite in Canada.

H. P. H. BRUMMELL. *Jour. Commerce*, **52**, 10 (1924); *Ceram. Abs.*, **3**, 317 (1924).—Canadian graphite material excels for crucible making. Canada promises to dominate the world's graphite industry. During the past few years the governments of the U. S., Great Britain, and Canada have been making exhaustive inquiries and investigations. It was not, however, until the advent of the oil frothing flotation method of concentration had been perfected that it was possible to supply Canadian graphite at prices which allowed any profit to the producer.

726. Graphite crucible.

E. RIETZ. U. S. 1,518,818, Dec. 16, 1924; *Ceram. Abs.*, **4**, 42 (1925).—The described crucible consisting of graphite and compounds of the titanium group of metals.

727. Materials for constructing vessel for high temperatures.

H. VON WARTENBERG. *Chem. App.*, **11**, 129–30 (1924); *Fuels and Fur.*, **3**, 699 (1925); *Ceram. Abs.*, **4**, 77, 252 (1925).—A summary of the properties of graphite, ZrO_2, quartz glass, hard porcelain, Pt, Pt-Ir (30%), Ir, W, and Ta, with a table showing maximum temperatures for use, substances by which attacked, permeability to gases, etc.

728. Graphite in western Australia.

WILSON. *Chem. Eng. and Min. Rev.*, **16**, 101 (1924); *Ceram. Abs.*, **3**, 102 (1924).—A report on the Mattigallup deposit of graphite by Wilson, Ass't State Mining Engineer. The graphite occurs in flat, shallow, undulating beds of kaolin or clay, in seams varying from 6 to 24 in. wide, which do not appear to be continuous for any great distance. In the No. 1 shaft a bulge seems to have occurred, there being 8 ft. of lode showing. The surface rock consists of hard ironstone laterite in which graphite can be seen in places, and at the bottom of the deeper shafts the country rock, which consists of kaolin, seems to lose its bedded character and may possibly represent the weathered portion of a more or less basic rock. While of low grade and too small for work on a large scale, W. calls attention to the comparatively low grade mines being worked in Canada by dry concentration, and by flotation units and electrostatic separators, and recommends some experimental work on these lines. The Mines Department is now considering giving financial assistance in the development work under the mining development act.

729. Graphite in Nyasaland.

ANON. *Jour. Soc. Chem. Ind.*, **44**, 219 (1925); *Ceram. Abs.*, **4**, 134 (1925).—Flake graphite which has been worked in Nyasaland is reported by the British Imperial Institute to be of excellent quality, equalling the best grades of the Ceylon mineral.

730. Highly-refractory article.

H. H. BUCKMAN AND G. A. PRITCHARD. U. S. 1,521,749, Jan. 6, 1925; *Ceram. Abs.*, **4**, 78 (1925).—As a new article of manufacture a highly refractory material permanently containing carbon in its graphitic form, and also a chemical compound of natural zircon.

731. Graphite melting point.

E. RISCHKEVITSCH. *Z. Elektrochem.*, **31**, 54–63 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 241 (1925); *Ceram. Abs.*, **4**, 195 (1925).—Carbon rods heated electrically in an atmos-

phere of argon melted at 3800° ± 100° Abs. The average temperature varied from 3450° Abs. at 0.005 atmosphere to 4330° Abs. at 1.5 atmospheres.

SPECIAL (A) Refractories

732. A new basic lining.

C. STOCKMANN. *Jour. Iron and Steel Inst.*, 417 (1883).—Strontia as a refractory.

733. Zirconia. A new refractory.

H. C. MEYER. *Met. Chem. Eng.*, **12**, 791 (1914); *Trans. Ceram. Soc.* (Eng.), **17**, 110A (1918); *Jour. Amer. Ceram. Soc.*, **1**, 838 (1918).—Geology, history, physical and chemical data, citations of actual use and bond are discussed for zirconia.

734. Refractory linings for furnaces.

O. SERPEK. U. S. 1,099,131, June 2; *C. A.*, 2788 (1914).—Making refractory furnace linings by lining the furnace with a mixture of C and Al_2O_3 and then transforming the surface of the lining into nitride by heating in an atmosphere of N.

735. Zirconia as a refractory material.

O. RUFF AND G. LAUSCHKE. *Sprechsaal*, **36**, 70 (1916); *C. A.*, **12**, 522 (1918).—Zirconia can withstand 2000° but is too porous for general use. Mix clay or SiO_2 with it and body is denser but can be used only up to 1700–1800°. Gives results of tests of additions of oxides to zirconia.

736. Zirconia refractory ware.

E. PODSZUS. *Zeit. angew. Chem.*, **30**, 17 (1917); *Jour. Soc. Chem. Ind.*, **36**, 217A (1917); *Trans. Ceram. Soc.* (Eng.), **16**, 46A (1917).—After being melted or heated above 2000° zirconia is very suitable for making refractory ware, as it is no longer liable to crack readily and break up. Description of method of manufacture. A very high uniform temperature with oxidizing atmosphere can be maintained without difficulty in a zirconia furnace up to 3000°F.

737. The production of highly refractory wares from non-argillaceous materials, particularly zirconia.

H. D. ARNOLD. *Chem. Ztg.*, **42**, 413–14, 426–28, 439–40 (1918); *C. A.*, **13**, 1251 (1919).—Gives physical data for zirconia and firing temperatures.

738. Zirconia as a refractory material.

L. BRADFORD. *Chem. Trade Jour.*, **62**, 284–85; *C. A.*, **12**, 1340 (1918).—Highest melting point of any metallic oxide. Non-volatile below melting point. Tends to form carbides. Troublesome cracking can be overcome by fusion in electric arc furnace. Coefficient of expansion is nearly as low as quartz. Fused ZrO_2 has a high crushing strength, great hardness, specific gravity of 5.89, porosity under 1%, melting point 2950°. ZrO_2 lining in a Siemens-Martin steel furnace at Remschied, reduced cost 50% and lasted 8 months. Engel in Berlin used 1–10% ZrO_2 for Zn retorts.

739. The partial purification of zirconium oxide.

A. J. PHILLIPS. *Jour. Amer. Ceram. Soc.*, **1**, 791–800 (1918).—Zirconium oxide is refractory and has low expansion, hence desirable as a refractory provided the crude ore can be freed from iron oxide. Several methods were tried, the one most successful being chlorination. The crude zirconia was mixed with about 4% of finely powdered petroleum coke, molded into small balls, and heated in an atmosphere of chlorine to 900°C. By introducing steam the iron oxide mixed with carbon is volatilized as the chloride, while zirconia is not affected. This reaction depends on hydrochloric acid gas.

740. Refractory products with a fixed volume, zircon, refractory mineral, and abrasive.

A. BIGOT. *Ceramique*, **37**, 191–93 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 1019 (1919) —The fusion point of zircon is above 2000°; at 1720°C it has a contraction of 0.55%. The use of 3–4% lime decreased the porosity. Fe oxide lowers the melting point. Zircon is resistant to both acid and basic slags.

741. Zirconia and its development for industrial purposes.

H. E. COLEY. *Chem. Trade Jour.*, **65**, 742 (1919); *C. A.*, **14**, 1018 (1920).—No real evidence has been presented to show that zirconia forms carbides. Has high shrinkage.

742. Zirconia, its utilization as a refractory, an opacifier, and an abrasive.

A. GRANGER. *Mineral Foote Notes*, **3**, Nos. 7 and 8 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 838 (1919).—Brazilian zirconia deposits at Pocas de Caldas are very extensive and contain 73–74% zirconium. Softening point of pure zirconia is 3000°C. Even with 1.25% silica and iron oxide it does not fuse below 2500°C. The thermal conductivity of the fused pure material is very low. Its coefficient of distillation is low (8.4×10^{-7}), which compares favorably with that of Carborundum (7.58×10^{-6}) or Alundum (7.10×10^{-6}). It is very resistant to abrupt changes of temperature and is chemically inert. Zirconium carbide forms easily when zirconia is heated to a high temp. in contact with carbon, the crucibles often becoming destroyed thereby. Specific conductivity of zirconia is 0.0008 at 1200°C and 0.0034 at 1400°C. Dr. Rieke (*Sprechsaal*, **1908**, 214), published the first researches on the use of zirconia as a refractory. The following methods for purifying zirconia are described: (1) treatment with hydrofluoric acid; (2) transformation into carbide; (3) treatment with sulphuric acid or bisulphates; and (4) alkaline fusion. For practical purposes treatment with hydrochloric acid is sufficient. In the manufacture of zirconia crucibles zirconium hydrate has been tried as a binder. The vessels, however, were too fragile and another binder was sought. Starch intimately mixed with zirconium hydrate and allowed to dry in air until it contained 9–10% zirconia was especially desirable. Moistened plaster-molds, having a wooden core covered with foil, could be used to mold crucibles. Two hours after molding crucibles are removed from mold, dried, and finally fired to 2000–3000°C in an electric furnace. Experiments in Germany showed that a lining of zirconia lasts a long time, and that in spite of the higher initial cost there was a saving of 50%. In metallurgy zirconia could also be employed in the preparation of copper and its alloys. Silicate of soda and tar are used with zirconia in forming the linings in furnaces. Lime may also be used in small quantities with zirconia, giving good results. Zirconia for laboratory use may be purified as follows: After a preliminary treatment with HCl the mineral is heated on a sand bath with H_2SO_4. The solution is evaporated to dryness and taken up with water. Zirconia can then be removed as follows: The addition of potassium sulphate precipitates a double sulphate; the addition of ammonia precipitates hydrated zirconium; the calcination of hydrate or sulphate of zirconium gives zirconia. Zirconia can be used as an opacifier in glazes. Although it increases the cost of a glaze it produces one which is very acid resisting. Because of its hardness zircon has been used as an abrasive for grinding mother-of-pearl. Grindstones for this purpose are not fired but cemented together.

743. Zirconia: its occurrence and application.

H. C. MEYER. *Trans. Ceram. Soc.* (Eng.), **18**, 264–75 (1919); *Jour. Amer. Ceram. Soc.*, **3**, 167 (1920).—Zirconia deposits are found in Brazil (most extensive), U. S., and Norway. Zirconium oxide is used as a refractory material and has possibilities of becoming a refractory of the first order because of its high melting point, low coefficient

of expansion and low thermal conductivity. Manufacture of zirconia products and their properties are described.

744. Carbon brick.

A. P. *Deut. Töp. Ziegler Ztg.* **53,** 219–20 (1920); *Ceram. Abs.*, **2,** 17 (1923).—Advantages of carbon brick are: their resistance to high temperatures, to sudden temperature changes, and to slag action. Seiger, *Stahl u. Eisen*, **41** (1912), says carbon brick are best suited for lining blast furnaces producing high carbon gray iron. Others say they are good for production of Thomas iron.

745. Resistance of zirkite to slag corrosion.

ANON. *Mineral Foote Notes*, May–June, 2–8 (1920); *Jour. Amer. Ceram. Soc.*, **3,** 689 (1920).—Zirkite brick are resistant to slag action with the exception of when fluorine or fluorine vapors are present.

746. Process of separating and extracting zirconium oxide (zirconia) from ores and minerals.

JOHN GORDON. U. S. 1,340,888, May 25, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 690 (1920).—The step in process of producing zirconia which consists in fusing minerals containing zirconium with a mixture of chloride and an oxide.

747. Refractory article and process for making same.

OTIS HUTCHINS. U. S. 1,362,317, Dec. 14, 1920; *Jour. Amer. Ceram. Soc.*, **4,** 242 (1921).—A shaped highly refractory article formed of a fired mixture containing zirconia and chrome oxide.

748. Refractory material and process of making it.

OTIS HUTCHINS. U. S. 1,362,316, Dec. 14, 1920; *Jour. Amer. Ceram. Soc.*, **4,** 242 (1921).—As a new article of manufacture, a highly refractory material consisting essentially of a fired mixture of zirconia and alumina.

749. Investigations on zirconium.

J. W. MARDEN AND M. N. RICH. *Jour. Ind. Eng. Chem.*, **12,** 651–56 (1920); *Jour. Amer. Ceram. Soc.*, **3,** 765 (1920).—The most satisfactory method of producing nearly pure ZrO_2 was as follows: One pound or a larger quantity of ore was slowly heated with four parts of concentrated H_2SO_4 until free of fumes and the temperature gradually raised to 650°C. After cooling the flour-like residue was extracted with 50 parts of cold water, filtered, and sodium carbonate added to neutralize any free acid until the zirconium hydroxide just began to form. The solution was allowed to stand 3 or 4 days, during which time the basic sulphate $4ZrO_2.3SO_3.14H_2O$ gradually separated out. When this was ignited a very high-grade ZrO_2 was obtained, which in one case contained 99.84% ZrO_2 and was free from any determinable trace of SiO_2. Exclusive of labor and equipment the cost for the production of 1 lb. of oxide by this method was about 20 cents. Data are given also on the preparation of pure K_2ZrF_6, the preparation and properties of zirconium metal, and the methods for analysis of zirconium ores.

750. Combination of material for fire bricks and refractory linings.

ARTHUR F. QUIN. U. S. 1,355,689, Oct. 12, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 1004 (1920).—A refractory composition comprising mica, asbestos and salt ground and mixed.

751. A new method for the determination of zirconium.

MELVIN M. SMITH AND C. JONES. *Jour. Amer. Chem. Soc.*, **42,** 1764–70 (1920); *Jour. Amer. Ceram. Soc.*, **3,** 1004 (1920).—The only reliable method, *viz.*: "cupferron," for the quantitative determination of Zr is impracticable commercially because of its

cost and its lack of simplicity with other elements present. The new method is based on the precipitation of basic selenite by H_2SeO_3 in acid (HCl) solution. Comparative tests by the cupferron method with known solutions showed the new method to be thoroughly accurate, the greatest difference between the two being 0.3%. Free H_2SO_4 should not be present and the solution should not contain over 7% concentrated HCl. The selenite precipitate is soluble in 10% free acid, but precipitation from 7% HCl gives no loss of Zr. Detailed procedure is given for preparation of H_2SeO_3 and for separation of Zr from Al, Fe, Ti, H_3PO_4 and the rare earths. To determine Zr in ore fuse it with 10 wt. of KHF_2 to a clear liquid, treat with 1 : 1H_2SO_4, and heat to fuming. Boil the residue with H_2O and dilute. Precipitate with NH_4OH (NH_4Cl present), wash the precipitate, dissolve in HCl, dilute, and precipitate with H_2SeO_3. Filter off the insoluble basic selenite, wash with 3% HCl, and ignite to ZrO_2.

752. The analysis of zirconium minerals.

H. V. THOMPSON. *Pottery Gaz.*, **45**, 767 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 690 (1920).—In the analysis of Zr ores two main difficulties are encountered, namely, (1) raw Zr ores and products manufactured therefrom are not easily decomposed, and (2) the separation of Al from Zr is not readily effected. It was decided to make use of the fact that after fusion with NaO_2 and decomposition of the melt with water, the residue contains all Fe, Ti, and Zr in the form of oxides, together with some of the SiO_2, while the whole of the Al and the remainder of the SiO_2 is contained in the filtrate. This process possesses the advantage that Zr and Al are automatically separated during the process of decomposing the sample.

753. Refractory article and process for making same.

FRANK J. TONE. U. S. 1,362,274, Dec. 14, 1920; *Jour. Amer. Ceram. Soc.*, **4**, 242 (1921).—As a new article of manufacture, a highly refractory material consisting essentially of a fired mixture of zirconia and sillimanite.

754. An approximate determination of the melting point diagram of the system zirconia-silica.

E. W. WASHBURN AND E. E. LIBMAN. *Jour. Amer. Ceram. Soc.*, **3**, 634–40 (1920).—(1) Melting point of pure ZrO_2 is about 2700°C; (2) melting point of natural zircon mineral is about 2550°C; (3) eutectic between ZrO_2 and $ZrSiO_2$ occurs about 2300°C; (4) iron may be completely removed from zirconia by heating to 300°C in current of phosgene.

755. Highly refractory article and method of producing same.

H. H. BUCKMAN AND G. A. PRITCHARD. U. S. 1,375,077, April 19, 1921; *Jour. Amer. Ceram. Soc.*, **4**, 865 (1921).—In the manufacture of a refractory composition, or material, the step consists in incorporating zircon into the batch.

756. Refractory material.

A. PFAFF. Can. 209,700, Mar. 22, 1921; *Jour. Amer. Ceram. Soc.*, **4**, 691 (1921).—A refractory material contains a fired mixture of about equal parts of zirconia and silicon carbide.

757. The preparation of zirconia from Brazilian ore and a new method of determination.

E. C. ROSSITER AND P. H. SANDERS. *Jour. Soc. Chem. Ind.*, **40**, 70–2T (1921); *Ceram. Abs.*, **1**, 181 (1922).—Solution of Brazilian ore is best effected by fusion of ore ground to flour fineness with an equal quantity of NaOH in an Fe crucible with continuous stirring until the mass becomes granular, after which the heat is maintained at dull redness for 2 hrs. The fused mass is extracted with water, then with HCl. The insoluble residue equals about 20% of the ore and contains: 61.55% ZrO_2, 29.32%

SiO_2, 1.10% Fe_2O_3, 1.80% Al_2O_3, 5.90% loss on ignition. The solution contains Zr oxychloride, Fe, Al, Ti, Mn, etc. It is diluted, treated with saturated SO_2 solution and heated to boiling. Sufficient NH_2SO_4 is added to replace the Cl in the oxychloride; Zr is deposited as basic sulphate, easy to filter, though very bulky. It is washed by decantation. ZrO_2 recovery is made by drying and igniting the hydroxide. The ZrO_2 contains 98–99% ZrO_2, some SiO_2 and Al_2O_3 and less than 1 part of Fe in 100,000. Properties of the basic sulphate and oxychloride are given. To determine ZrO_2 in presence of Fe and Al 7 cc. H_2SO_3 and 2 cc. of H_2SO_4 are used for each 0.2 grams of ZrO_2. The solution should be diluted to 150 cc. for each 2 cc. H_2SO_4. Difficulty due to formation to H_2SO_4 in the reaction is overcome by boiling, after the addition of SO_2 solution until Fe is completely reduced. Complete separation from Fe_2O_3 is obtained in proportions up to 1 : 3½ but, with larger proportions of Fe the basic sulphate is slightly soluble in the $(NH_4)_2SO_4$ and NH_4Cl formed during neutralization.

758. Fused zirconium oxide articles.

A. L. D'ADRIAN. U. S. 1,430,724, Oct. 3, 1922; *Ceram. Abs.*, **2**, 53 (1923).—ZrO_2 is finely ground, mixed with a binder such as starch or molasses and molded into tubes, blocks, crucibles, or other articles, heated to dull redness between C electrodes and then heated by resistance to above 2500° to fuse the particles together.

759. Zirconium and zirconium oxide.

L. ANDRIEUX. *Ind. chim.*, **8**, 478–81 (1922); *Ceram. Abs.*, **1**, 209 (1922).—A review of the occurrence, properties, and applications of ZrO_2, and of the preparation, properties, and applications of Zr, with a bibliography of 21 references.

760. Crucibles.

M. BOÏBOUL. Brit. 179,928, May 5, 1922; *Ceram. Abs.*, **2**, 53 (1923).—(Addition to Brit. 165,051.) Crucibles for fusing refractory minerals are composed of a mixture of the oxides of Zr, Y, Th and Er, suitable proportions being Zr oxide 60–80%, Y oxide 13–17%. Th oxide up to 10%, and Er oxide 5–20%. The Th oxide may be omitted. Rare earths, such as Ce oxide, may be added to the foregoing ingredients in proportions up to 20%. Ce oxide or Be oxide may be substituted for the Er oxide.

761. Refractory composition.

H. H. BUCKMAN AND G. A. PRITCHARD. U. S. 1,412,916, Apr. 28; *Ceram. Abs.*, **1**, 255 (1922).—A material adapted for making retorts, muffles or crucibles is formed of zircon and a refractory clay.

762. Refractory composition.

C. A. FRENCH. U. S. 1,418,372, June 6; *Ceram. Abs.*, **1**, 280 (1922).—Zr oxide and steatite are used together to form a composition adapted for crucibles, furnace linings or spark plug insulators.

763. A new refractory material.

W. SMITH. *Jour. West Scot. Iron and Steel Inst.*, **30**, 8–13 (1922); *Ceram. Abs.*, **2**, 101 (1923); *C. A.*, **17**, 619 (1923); *Tonind. Ztg.*, **47**, 530 (1923); *Ceram. Abs.*, **2**, 282 (1923).—Clay is impregnated with C by heating it together with coal at low temperatures. The clay thus treated may be bonded with tar and the products made in this manner are fired before using. It is claimed that this will make an excellent refractory, being very resistant to slag action. Will stand highest commercial temperature and is not affected by acids when used under reducing conditions.

764. Zirconium and its compounds.

F. P. VENABLE. The Chem. Catalog Co., New York; *Ceram. Abs.*, **1**, 172 (1922).—A thorough compendium of this subject. The book takes up the history, the reduction,

and properties of the metal, and the compounds of the various classes in an orderly way. It closes with analytical methods and technical applications. Then follows a complete list of patents with abstracts of each and a complete bibliography. In this the author's twenty original contributions deservedly shine. The text is replete with references.

765. Refractory heat-insulating material.

P. G. WILLETTS. U. S. 1,374,538, Apr. 12; *Ceram. Abs.*, **1**, 68 (1922).—A refractory material adapted for boiler settings or the like is formed by firing a mixture of finely divided lignite coal and plastic fire clay having a high silica content.

766. Refractory articles containing zircon.

H. H. BUCKMAN AND G. A. PRITCHARD. U. S. 1,440,657, Jan. 2, 1923; *Ceram. Abs.*, **2**, 132 (1923).—Muffles, crucibles or similar refractory articles are formed of zircon and carborundum.

767. Refractory articles containing zircon.

H. H. BUCKMAN AND G. A. PRITCHARD. U. S. 1,440,766, Jan. 2, 1923; *Ceram. Abs.*, **2**, 132 (1923). Retorts, muffles or other refractory articles are formed of zircon and SiO_2 or clay. Cf. *Ceram. Abs.*, **1** [3], 68 (1922).

768. Materials for furnace walls.

J. H. GRAY. U. S. 1,439,410, Dec. 19; *Ceram. Abs.*, **2**, 132 (1923).—Bricks for furnace walls are formed mainly of a carbonaceous material such as calcined anthracite mixture with a facing layer of another refractory material more resistant to oxidation, *e.g.*, MgO clay and SiO_2, Cr ore or zirconia.

769. Refractory compositions containing zirconia.

G. KALLEN. Brit. 221,852, June 12, 1923; *Ceram. Abs.*, **4**, 136 (1925).—Refractory articles are made by firing a mixture of crude Zr ore and a plurality of different binding ingredients which soften progressively with increase in temperature such as water-glass, glass of low melting point, dolomite, feldspar, Portland cement, magnesite, clay, or bauxite; *e.g.*, Zr ore 88, dolomite 9 and feldspar 3 parts are mixed with a 3% water-glass solution, molded, and fired at about 1000°. A fireproof paint is formed from Zr ore 40, water-glass 20, dolomite 20, casein 5, and H_2O 20 parts.

770. Action of high temperatures on some refractory substances.

CAMILLE MATIGNON. *Compt. rend.*, **177**, 1290–93 (1923); *Ceram. Abs.*, **4**, 78 (1925); *C. A.*, **18**, 738 (1924).—Samples were heated in a C-resistance furnace in a stream of N_2. I. $Na_2O.Al_2O_3$. Aluminates richer in Na_2O lost Na_2O by dissociation below 1650°. II. Zr silicate crystallized Brazilian zircon did not melt at 2126°. There is a possibility that zircon might be heated to give ZrO_2. III. Zircite. The natural oxide does not melt at 1950°. IV. WO_2 is reduced under conditions of experiment to metal and carbide but does not melt. V. AlN does not melt at 2200°. The crystallized form is only slowly attacked by O_2 at high temperatures.

771. Zirconia refractories.

MARK SHEPPARD. *Jour. Amer. Ceram. Soc.*, **6**, 294–96 (1923).—Outline of physical properties of zirconium ore. Mention of zirconia laboratory ware and method of manufacture. Manufacture and physical properties of zirconia brick. Zirconia cement and its uses.

772. A new refractory material.

W. SMITH. *Tonind. Ztg.*, **47**, 530 (1923); *Ceram. Abs.*, **2**, 101 (1923); *ibid.*, **2** 282 (1923); *Jour. West Scot. Iron & Steel Inst.*, **30**, 8–13 (1922); *C. A.*, **17**, 619 (1923).—Clay is impregnated with C by heating it together with coal at low temperatures. The

clay thus treated may be bonded with tar and the products made in this manner are fired before using. It is claimed that this will make an excellent refractory being very resistant to slag action.

773. A heat insulator and filler aid.

ANON. *Chem. Met. Eng.*, **31**, 973–74 (1924); *Ceram. Abs.*, **3**, 107 (1924).—A description of the deposits and plant of the Celite Products Co.

774. High refractories.

ANON. Ger. Pat., 371,675. *Chem. Tech. Uebersicht*, 192; *Chem. Zeit.*, **48**, 130–32 (1924); *Ceram. Abs.*, **4**, 107 (1925).—Substance from zirconium oxide, silicon carbide, and quartz.

775. Keramonit and thermonit.

H. BECK. *Feuerungstech.*, **12**, 97–98 (1924); *Stahl u. Eisen*, **44**, 644–45 (1924); *Ceram. Abs.*, **7**, 289 (1924).—Two new refractories.

776. Refractory article and process of making same.

H. S. COOPER. U. S. 1,491,224, April 22, 1924; *Ceram. Abs.*, **3**, 221 (1924).—A refractory article consisting of zirconia bonded by relatively fusible impurities therein, said impurities being present in amounts not substantially impairing the refractory properties of the article.

777. Thermal conductivity and some other properties of two commercial heat-insulating bricks used in kiln construction.

A. T. GREEN. *Gas Jour. Suppl.*, 29–31, July 9, 1924; *Trans. Ceram. Soc.* (Eng.), **23**, 271 (1924); *Ceram. Abs.*, **4**, 134 (1925); *C. A.*, **19**, 3357 (1925).—Two batches of kieselguhr bricks were examined. Both had 15% cork and sawdust and one had an additional 10% of clay. The refractoriness of both was low and one began to shrink appreciably at 900°, the shrinkage being accompanied by a great increase in thermal conductivity. For high-temperature insulation purposes the kieselguhr should be purified so that the brick contains at least 92% of silica.

778. Thoria-crucible production.

H. K. RICHARDSON AND T. M. SWITZ. U. S. 1,512,801, Oct. 21, 1924; *Ceram. Abs.*, **4**, 17 (1925).—As a slip for casting refractory ware a homogeneous mixture of incompletely shrunk thoria, grog, a medium adapted to serve as a colloid, a reagent capable of developing an electrolytic action in the presence of water, in the proportion of 40, 20, 5, and 2 parts, respectively, and water to the desired consistency. The method of making thoria ware, comprising forming a slip of thorium oxide, grog, a double halide salt adapted to serve as a colloid, a reagent capable of developing an electrolytic action in water, and water, subjecting said slip to a vacuum to exhaust any gases therein and casting.

779. Diatomite.

A. W. ALLEN. *Eng. Min. Jour.-Press*, **119**, 96 (1925); *Ceram. Abs.*, **4**, 105 (1925).—The diatomite mining industry showed expansion in 1924 due to a wider use of this material. Research indicates a wider use of this material in the near future.

780. The refractory nature of common high temperature oxides.

J. BROWN. *Feuerfest*, **1**, 25 (1925); *Ceram. Abs.*, **4**, 278 (1925).—Nearly all the refractory materials used are in the form of oxides, *i.e.*, Al_2O_3, CaO, MgO, SiO_2 and Cr_2O_3, Fe_2O_3, FeO, TiO_2, ZrO_2. The need for closer investigation of the properties under high temperature of this latter group is brought out and now made possible by development of the electric furnace.

781. Refractory material.

G. S. FULCHER. Can. 248,315, Mar. 31, 1925; *Ceram. Abs.*, **4**, 347 (1925).—A crystalline refractory contains SiO_2, Al_2O_3, zirconia and alkaline silicate.

782. Process for refining zirconium-containing ores and other products containing dioxide of zirconium.

OTTO RUFF. U. S. 1,535,687, April 28, 1925; *Ceram. Abs.*, **4**, 196 (1925).—The process of refining zirconium containing ores or products containing dioxide of zirconium, which comprises heating the same with a haloid salt of zirconium or with materials forming such haloid salt, at a temperature sufficient to vaporize the resultant haloid salts of the contaminating elements.

783. Art of manufacturing zirconium compounds.

L. W. RYAN. U. S. 1,530,139, Mar. 17; *Ceram. Abs.*, **4**, 135 (1925).—The method of manufacturing zirconium compounds which comprises decomposing a siliceous zirconium ore with not more than twice its weight of sulphuric acid, neutralizing the free acid in the resulting solution, precipitating a granular basic zirconium sulphate from said solution and separating the precipitated granular basic sulphate.

SPECIAL (B) Use

784. Production of zinc retorts and their behavior in the fire.

OTTO MUHLHAUSER. *Zeit. f. angew. Chem.*, **16**, 273 (1903); *Trans. Ceram. Soc.* (Eng.), **17**, 36A (1917).—Gives the manufacture of zinc retorts from St. Louis clay, their firing schedule and temperature changes in firing and use, and the condition of the retorts after use.

785. German gas-retort manufactures.

ANON. *Brit. Clayworker*, **17**, 222–24 (1908); *C. A.*, **3**, 698 (1909).—Clay made into a soup, mixed with grog, and dried to proper consistency. Most retorts are glazed internally, but lead or salt glazes should not be used. Firing temperature should exceed that of actual uses and should be less than 70–80 hours.

786. A method of testing sagger mixes.

H. E. ASHLEY. *Trans. Amer. Ceram. Soc.*, **12**, 277–95 (1910).—Test bars were bent to test for sagging and plunged in cold water to represent splitting and cracking test. Test pieces had 50% grog. No piece carried much weight on first firing. Quartz should be kept low. Crushed earthenware not a grog. Grog works well. Resistance to bending and cracking due to temperature change had no relation. Best saggers from coarse grained clay of high colloid content and carrying much grog.

787. Palmerton zinc refractories.

C. P. FISKE. *Trans. Amer. Inst. Min. Eng.*, **57**, 868 (1917).—Manufacture, raw materials, test, etc., of spelter vessels, condensers, and high grade fire brick.

788. Notes on sagger clays and mixtures.

G. H. BROWN. *Jour. Amer. Ceram. Soc.*, **1**, 716–29 (1918).—Gives causes of failure, mixes, etc.

789. The preparation of raw materials for, and the manufacture of glass house pots.

B. J. ALLEN. *Jour. Soc. Glass Tech.*, **3**, 78–93 (1919); *Jour. Amer. Ceram. Soc.*, **2**, 908, 1017 (1919).—Impure fire clay can be increased greatly in quality by deflocculation and precipitation of the coarse particles. It also increases the plasticity, thereby allowing the use of a larger quantity of grog. Use of slip gives a better mixture than pugging.

790. A study of some light weight refractories.

M. F. BEECHER. *Jour. Amer. Ceram. Soc.*, **2**, 336–55 (1919).—Descriptions are given of composition, structure, and properties as disclosed by tests. Discussions by Ross, Riddle, Howe, and Clare show the desirability and use of light refractories especially in marine boilers. Data are given and tests described.

791. Superior refractories.

R. C. PURDY. *Jour. Amer. Ceram. Soc.*, **2**, 864–69 (1919).—This is a statement of the need of a survey of the industrial requirements for superior refractories, a review of the inadequacies of present knowledge of how to produce, and a plea for investigations by federal bureaus.

792. Control of the sagger mixtures.

V. S. SCHORY. *Jour. Amer. Ceram. Soc.*, **2**, 747–50 (1919).—As a rapid means of determining the most practical clay mixture for saggers it has been found that the clay mixture (without grog) should show absorption of not under 2.5% and not over 4% when bars are fired to cone 11, 3.25% being the average best figure. When such a mixture of clays is used as the clay content of the sagger mixture the results are satisfactory. Possibly at other factories a 3.25% absorption figure may not be the best.

793. Glass tank furnace.

L. T. SHERWOOD. U. S. 1,325,172, Dec. 16, 1919; *Jour. Amer. Ceram. Soc.*, **3**, 169 (1920).—Water boxes are maintained in close contact with the outer surfaces of glass tank walls at the glass level. The walls thus cooled do not disintegrate so rapidly as they otherwise would.

794. Refractory crucibles.

ANON. *Metal Ind.*, **17**, 369 (1920); *Ceram. Abs.*, **1**, 106 (1922).—Crucibles can be manufactured by tapping plastic mixtures of highly refractory oxides into fire-clay molds lined with plaster of Paris and then firing the crucibles and the mold to a red heat. The crucible can then be removed and given a further firing at high temperature. Another method is to use linseed oil as a temporary binder, the crucible being shaped in a metal mold. Crucibles have been made in this way from TiO_2ZrO_2 and CaC.

795. German naval specifications for fire brick used in boiler settings.

ANON. *Mitt. Breenkraftech. Ges.*, **2**, 56; **8**, 57–59; *Tonind. Ztg.*, **44**, 1097 (1920); *C. A.*, **15**, 1977 (1921).—Specifications for refractories for the different parts of the boilers.

796. Light weight refractories.

ANON. *Tonind. Ztg.*, **44**, 718 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 765 (1920).—Good insulators for furnaces have for some time been made by adding sawdust, coal, and kieselguhr to clay and firing same. In Asia Minor there is a type of kieselguhr which has sufficient strength so that it may be sawed and cut into brick. Such brick need not be fired. It is suggested that this material would make excellent insulation for buildings.

797. Refractories for glass furnaces and melting walls.

J. BALDERMAN. *Tonind. Ztg.*, **44**, 581–82, 612 (1920); *Jour. Amer. Ceram. Soc.*, **3**, 765 (1920).—Grog should never be greater than 3 mm. and should be fired high enough to remove all of the shrinkage. Often coarse quartz is added to glass refractories which is poor practice since these particles are dissolved by the glass, leaving a honey-comb effect. Old pots make excellent grog since all the shrinkage is fired out.

798. Heating of retort settings. Some theoretical considerations in the design of gas works plant.

G. DOUGILL. *Gas Jour.*, **152,** 454–56 (1920); *Gas World*, **73,** 428–29 (1920); *Jour. Amer. Ceram. Soc.*, **4,** 240 (1921).—The vertical retort lends itself most readily to efficient heating, the horizontal retort is most difficult, and the coke oven occupies an intermediate position. The efficiency of the horizontal retort is reduced by the supporting walls, and it is proposed that thinner walls at shorter intervals would produce better heating without diminishing the mechanical strength. In horizontal-retort plants where outside producers are installed, it would be well to follow coke-oven practice and build the retorts in vertical lines and the combustion chambers at each side of the retort with recuperators.

799. Heat insulating brick.

J. C. EMLEY. U. S. 1,330,249, Feb. 10, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 411 (1920).—This is a brick particularly adapted for the outer walls of ovens, and having a vitreous or glass face and a heat-insulating backing keyed thereto. The heat-insulating backing consists of infusorial earth and a heat-resisting cement binder.

800. The art of pot making.

O. GRAFTON. *Jour. Amer. Ceram. Soc.*, **3,** 653 (1920).—Methods are described and illustrated for making of glass pots.

801. Method of testing sagger mixtures.

S. C. LINBARGER AND C. F. GEIGER. *Jour. Amer. Ceram. Soc.*, **3,** 543–55 (1920).—No definite statement can be made that modulus of rupture at 1300° is directly proportional to sagger life but it seems likely. Life tests are now under way to prove it. Apparently any sagger mix with high modulus at 1300° (say over 350 lbs. per sq. in.) can be made into a good sagger. The testing equipment as described is simple and inexpensive. Probably no other tests are needed.

802. Light-weight refractory brick.

ROSS C. PURDY AND MILTON F. BEECHER. U. S. 1,345,632, July 6, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 766 (1920).—A composition of matter for a porous brick, comprising a fired refractory lignite clay mass.

803. Refractory and protective coating on furnace linings.

E. R. STOWELL. U. S. 1,350,343, 1920; *Ceram. Abs.*, **1,** 109 (1922).—Mix 8 lbs. powdered SiC with 1 gal. of 4% solution of NaOH with water, stir, and add 1 part of a 50° Bè solution of sodium silicate.

804. The casting of pots for use in experimental work on optical glasses.

ALICE B. TAYLOR. *Jour. Soc. Glass Tech.*, **4,** 140–52 (1920); *Jour. Amer. Ceram. Soc.*, **3,** 923 (1920).—The water content of a pot mixture for casting should be about 20%. The experimental pots cast were only 9 in. in diam. The mixture was 3 parts china clay to 2 parts of grog, fired to cone 18 and sieved to 20-mesh (sometimes 30-mesh). Sodium carbonate and sodium silicate, $\frac{1}{8}$ of 1% each, were added. Casting under the pressure of a column of slip being fed in at the center of the bottom developed ring cracks in the bottom. Casting under air pressure and with the slip fed in at the center of the bottom was satisfactory. A pipe from the pressure tank containing the slip led up to the bottom of the pot mold. The initial air pressure for these small pots was 20–25 lbs. per sq. in. After filling the pressure was reduced to 10 lbs. and kept there for 45–60 min. until the pot had solidified, when it was taken from the mold to complete the drying. The best casting was obtained with slip density of 1753 grams per liter. Distribution of

grog through the pot wall was studied by taking air-dried fragments from various locations; heating them up slowly to about 500°C, then rapidly in a blowpipe to about 100–200°C below the temerature of calcination of the grog. These fragments were then ground on a Carborundum wheel, then on fine Carborundum and emery, and finally polished on a pad with rouge. The grog particles then stood out plainly.

805. Method and means for producing saggers.

F. J. WOLFF. U. S. 1,337,871, Apr. 20, 1920; *Jour. Amer. Ceram. Soc.*, **3**, 599 (1920). —The sagger body is expressed in sheet form through a die having the width and thickness desired in the slab produced. This die is lubricated by means of a series of small pipes radially disposed about the condensing nozzle and projecting slightly into the clay, forming grooves. The lubricant is fed into these grooves through the small pipes. The ribbon emerging from the die is cut into desired lengths and made into saggers. A better distribution of the grog is said to result from this method than can be obtained from other machine methods of forming saggers.

806. The manufacture and treatment of glass melting pots.

W. K. BROWNLEE AND A. F. GORTON. *Jour. Amer. Ceram. Soc.*, **4**, 97–112 (1921).— 1. Manufacture of glass melting pots. The raw materials used, the methods of grinding and mixing the raw clay and grog, and the way in which pots are built and dried are briefly described for the purpose of impressing glass makers with the amount of labor and care involved. At present only one grade of pot is made; but the difficulty of getting a pot suitable for all kinds of glass suggests the desirability of making special grades of pot for use with specified kinds of glass. 2. Proper treatment of pots by the glass maker. The authors emphasize the importance of gently handling pots and of storing them in a warm and dry place. The precautions to be taken in preheating pots in arches are discussed at length for this is the critical period in the life of the pot. The batch should be properly crushed and mixed and should either be preheated or loaded in gradually; and the furnace temperature should be carefully regulated. It is particularly urged that the technical treatment of pots in the glass be entrusted to a man trained in ceramics and physical chemistry. 3. Arches for heating glass melting pots. After discussing the usual design the authors suggest improvements as to fire box locations, construction of walls and door, etc.

807. Note on sagger clay preparation.

F. K. PENCE. *Jour. Amer. Ceram. Soc.*, **4**, 459–60 (1921).—Saggers can be improved in quality by installing a mixing machine immediately following the dry pan. The soaking pit may then be eliminated and the clay and water fed directly to the pug mill. This process permits of large tonnage and is of course also applicable to other bodies.

808. National review of the sagger situation.

GEORGE SIMCOE. *Jour. Amer. Ceram. Soc.*, **4**, 393–406 (1921).—A questionnaire sent to a number of clay manufacturers elicited the information: (1) better sagger cost system needed; Carborundum and $x\mathrm{NaO}y\mathrm{SiO}_2$ Na SiO are frequent constituents of the sagger body; (3) jaw crusher better than pan grog; (4) sagger containing 30% Carborundum and lasting 20 or more fires is economical.

809. Sagger bodies and tests of same.

W. STEGER. *Trans. Ger. Ceram. Soc.*, **2**, 142 (1921); *Ceram. Abs.*, **1**, 321 (1922).— Unusual ingredients mentioned are magnesite, corundum, zirconium oxide, Carborundum.

810. Glass house refractories.

ANON. *Pottery Gaz.*, **47**, 727, 729, 731, 733, 735 (1922); *Ceram. Abs.*, **2**, 129 (1923).— A lengthy discussion of failures in refractory materials for glasshouse use.

811. Sagger investigation.

ANON. *Brick and Clay Rec.*, **61**, 960 (1922); *Ceram. Abs.*, **2**, 104 (1923).—Bureau of Standards is testing 52 different sagger clays sent by the consumers in order to locate the causes of sagger losses. Clays for classification purposes will be tested for water of plasticity, shrinkage, porosity, transverse strength and firing behavior at 5 different cones.

812. Refractory brick.

GEORGE A. BALZ. U. S. 1,410,729, March 28, 1922; *Ceram. Abs.*, **1**, 210 (1922).—A refractory brick consisting of a body portion and a facing portion relatively shaped to mechanically engage one another and united only by such engagement.

813. Furnace linings.

C. H. BREERWOOD. U. S. 1,380,700, June 7; *Ceram. Abs.*, **1**, 68 (1922).—A refractory material suitable for lining furnaces or for making crucibles is prepared by introducing dolomite and Fe or similar material adapted to form a sinter in a finely divided condition into a furnace, mixing with it small pieces of coal tar, Fe, fire brick, or other material to which the finely divided material adheres in its passage through the furnace to form balls, and continuing the heating for a sufficient time to aggregate the materials to the desired extent.

814. Refractory cover for electric furnaces.

M. S. CLAWSON. U. S. 1,410,654, Mar. 28, 1922; *Ceram. Abs.*, **1**, 234 (1922).

815. Refractory furnace linings.

E. CONE AND J. W. HALE. Eng. 199,154, March 17, 1922; *Ceram. Abs.*, **2**, 282 (1923).—The inner lining of the furnace is constructed of a wall, one brick thick and the space between it and the outer wall filled with a rammed-in plastic mass of the composition: graphite 50, fire clay 25, silica rock 5, magnesite 5, anhydrous gas tar sufficient to render plastic. Alternatively the plastic mass may extend with the brick-work in layers to the inner surface of the furnace. The method is applicable to basic, neutral, or acid refractory materials.

816. Physical defects in tank blocks.

GEO. A. LOOMIS. *Jour. Amer. Ceram. Soc.*, **5**, 102–106 (1922).—An investigation of some of the leading makes of tank blocks of flux grade tends to show that these blocks as a class, are not as free of physical defects, such as fissures and lamination, as could be desired. Photographs are shown of representative sections of the blocks examined.

817. Note on ladle brick.

D. A. MOULTON. *Jour. Amer. Ceram. Soc.*, **5**, 823–25 (1922).—Review of literature of ladle brick: (1) American ladle in which is stated no chemical reactions occur; (2) English ladle in which four or five chemical reactions occur simultaneously. Fusion point of ladle brick ranging from cones 17 to 30 depending on behavior of clay at temperatures below the fusion point. Process of manufacture: Two processes, namely, dry press and stiff-mud with preference for dry press. Modification of standard refractories is suggested.

818. Refractories for coke-oven construction.

W. J. REES. *Fuel*, **1**, 20–22 (1922); *Ceram. Abs.*, **2**, 18 (1923).—The relative values of different materials for by-product coke ovens are shown by experiments: SiO_2, siliceous fire clay, semi-SiO_2 and fireclay bricks were exposed to NaCl vapor (with and without H_2O vapor) at 800–1200°. The attack was much greater on the bricks containing clay than on the SiO_2, the maximum attack occurring with the fire clay,

particularly at 900–1100°. The NaCl vapor penetrates the bricks, and the result of the slow interaction in the cooler portion and the rapid action in the hot part is to form a vesicular mass. This opens the bricks to further attack with disintegration. Experiments on a large scale, using salty coals, indicate that formation of $FeCl_2$ and NH_4Cl play an important rôle. Facing or glazing the exposed faces failed, owing to differential expansion.

819. Critical review of the provisional specifications for glass refractory materials.

W. J. REES. *Jour. Soc. Glass Tech.*, **6**, 181–204 (1922); *Ceram. Abs.*, **2**, 94 (1923).—(1) *Silica brick.* For bricks to be used in such positions as furnace pillars, it might be well to specify a powder density of 2.35 so as to insure at least 80% conversion into tridymite; but for bricks to be used in crowns such a stipulation may not be necessary or desirable. A specification as to mechanical strength would be desirable. It was pointed out that exposure to a moist atmosphere diminishes the mechanical strength markedly. Special specifications for bricks to be used in regenerator chambers are also needed. (2) *Tank blocks.* There is great need for more information as to the causes of block failure, whether due to the particular melting conditions or to the materials or manufacture of the block. In some tanks the corrosion is not greatest at the metal line but may be worse on the lower blocks, due probably to mechanical corrosion. Tanks should always be raised to a high temperature before the filling is begun. The two most important factors governing the life of a block are porosity and uniformity of texture. Results of tests of 8 makes showed that the two blocks with porosity of only 21 and 19% and with after-contraction of only 1.4 and 0.8% gave the best service, one lasting 18 months in a tank furnace melting a salt-cake batch. The grog should be of the same clay or at least have the same solubility as the rest of the block. Perhaps unweathered clay would be better than weathered clay. Methods of test are discussed. A small special tank seems best. The practical difficulties of producing uniform blocks are very great. Coöperation between block makers and users is necessary for best progress. In the discussion, it was suggested that since small blocks are more easily made uniform than larger ones, they should be tried. (3) *Pot clays.* The specifications are decidedly debatable. Though there is a tendency to use aluminous clays, siliceous clays give greater strength and show less shrinkage.

820. Coöperative research on sagger mixtures and manufacture.

C. C. TREISCHEL. *Bull. Amer. Ceram. Soc.*, **1**, 101–106 (1922).—A plan is suggested for coöperative research on saggers.

821. Refractories for the aluminium industry

R. J. ANDERSON. *Metal Ind.* (London), **23**, 441–42 (1923); *Ceram. Abs.*, **3**, 45 (1924).—(Abstract of paper before Refractories Division, AMERICAN CERAMIC SOCIETY.) A. discusses refractories for melting substantially pure aluminium and aluminium alloys, both from the point of view of the setting for furnaces and use as the containing vessel or hearth. While required melting temperatures are low, the corrosive action of liquid aluminium is great, causing failure of refractories. Carbon is used for lining furnaces for the electrolytic reduction of primary aluminium. This is re-melted for pigs or ingots in reverberatory type furnaces. Reverberatory furnaces with high-grade firebrick lining are usually employed in rolling-mill practice for melting substantially pure aluminium. Alloys are usually melted in iron-pot or crucible furnaces unless production is large, when reverberatory furnaces are used. The various types of furnaces used in light-alloy foundry practice are discussed. The iron-pot furnace is most favored; in this, the shell is lined with fire brick and the alloy melted in a cast-iron vessel, usually

made of ordinary gray foundry iron, but sometimes of a mixture of 40% semi-steel and 60% foundry iron. The average life is about 40 heats. Further research is needed on question of refractories and containing vessels for melting in die casting and permanent-mold casting practice. Present iron-pot methods are not satisfactory owing to dissolution of iron. Alundum linings are not successful. The linings for furnaces in secondary smelting of aluminium and aluminium alloys is an important factor. The life of furnace linings in secondary work is low owing to local firing. Reverberatory, crucible, and iron pots are used, and requirements are severe owing to the high temperature generated by the oxidation of aluminium and the use of fluxes which are destructive to linings.

822. A note on the requirements of sagger bodies.

M. F. BEECHER. *Bull. Amer. Ceram. Soc.*, **2**, 251–53 (1923).—A discussion of requirements in raw materials for saggers.

823. Arch brick.

GUY CARLETON DENNEY. U. S. 1,463,156, July 31; *Ceram. Abs.*, **2**, 257 (1923).—An arch brick member having along one edge an arch brick support engaging surface and having on its opposite edge a cut-back portion having an inclined end surface and a projecting portion having an oppositely inclined end surface, the planes of said surfaces not intersecting within the body of the member and said portions being complementary, whereby when a pair of such members are assembled in reversed relation they coöperate to form a brick, said inclined end surfaces being serrated or roughened.

824. The casting process for glass refractories in German glass tank process.

K. ENDELL. *Pottery Gaz.*, **48**, 1964–67 (1923); *Ceram. Abs.*, **3**, 198 (1924).—The principal advantages of the casting process compared with older methods of making pots by hand are (1) a very homogeneous mixture of the raw clay and grog is obtained, which results in a close texture after firing; (2) unskilled labor is employed in place of highly rated men. The process is not only used for the casting of pots but also for producing large tank blocks and slabs. The difficulty arising in a wider adoption of the process lies in the discovery of suitable casting clays. The suitability of a clay for casting depends upon the possibility of obtaining with the clay and grog mixture a pouring consistency suitable for casting by the addition of about 0.25% alkali and 18 to 20% water calculated on dry weight of the mixture. Many clays which are suitable for making glass pots require too much water to produce a casting slip; for example, grossalmerode pot clay and Belgian crucible clay from Ardenne region. The difficulties with these clays are due principally to soluble salts such as sulphates. Work is now in progress on freeing clays of soluble salts by electrolysis. In certain clays fluidity can be improved by a small addition of sulphate lye. No difference in refractoriness could be detected in Seger cones between cast and hand-made pots, and no perceptible difference was noted between the 2 methods when tested for ability to withstand load at elevated temp. Introduction of finely divided quartz as such or in the form of raw china clay into fireclay mixtures increases the rigidity of the fire clay at high temperature. Cast pots are approximately 25% denser than hand-made pots, which gives preference to cast pots in melting special glasses, such as heavy barium glass, which attack fire clay readily. The porosity of cast pots gave values between 19 and 22% whereas hand made pots of the same clay approximated between 24 and 26%. Success of the casting process depends upon careful and trained supervision, proper selection, and preliminary treatment of clay.

825. Further studies on cast glass pots.

R. F. GELLER AND A. N. FINN. *Jour. Amer. Ceram. Soc.*, **6**, 865–72 (1923).—This is a progress report covering the work done by the Bureau of Standards during the past

three years on the problem of cast glass pots. The work done is essentially an application of the results of research reported in previous Bureau publications and contains data on body compositions, the arching of pots, and their resistance to optical glass. The following conclusions were made: (*a*) The casting of porcelain glass pots has passed the experimental stage; (*b*) The content of plastic clay is not of prime importance as long as the body will cast satisfactorily; (*c*) Proper watersmoking practically eliminates fissures and surface cracks; (*d*) Pots should be arched to the highest temperature consistent with the refractoriness of the body.

826. Metallurgical requirements of refractories for furnaces melting copper alloys.

H. W. GILLETT. *Jour. Amer. Ceram. Soc.*, **6**, 596–609 (1923).—The requirements for refractories for pit furnaces are less severe than for those for open-flame or electric furnaces. Suitable refractories for electric furnaces will meet the needs of the other types as well. Attention is therefore directed to the development of better refractories for electric furnaces melting non-ferrous alloys. The most important types of electric brass furnaces are described in relation to their refractory problems. The requirements vary with the type of furnace. All types require refractories that will resist penetration by metal, will not spall or crack, have a low thermal conductivity, and high mechanical strength at working temperatures. A refractory combining these properties in sufficient degree would be welcomed by users of copper-alloy furnaces, especially electric furnaces, and a rather high price would not be an insurmountable barrier to its use if it will markedly increase the lining life.

827. Sagger colloquium.

W. A. HULL. *Bull. Amer. Ceram. Soc.*, **2**, 253–63 (1923).—A follow-up of the plan suggested by Treischel for coöperative research on saggers.

828. Discussion on "Tentative specifications for glasshouse refractories."

D. W. ROSS. *Bull. Amer. Ceram. Soc.*, **2**, 29 (1923).—A detailed outline of specifications for glasshouse refractories is given.

829. Refractory material for zinc retorts.

W. F. ROSSMAN. U. S. 1,424,120, July 25; *Ceram. Abs.*, **2**, 53 (1923).—A refractory material for manufacture of retorts is formed of plastic clay, finely pulverized SiO_2, and ground grog about equal in amount to the SiO_2.

830. The behavior of fire brick in malleable-iron furnace bungs.

H. G. SCHURECHT AND H. W. DOUDA. *Jour. Amer. Ceram. Soc.*, **6**, 1232–41 (1923).—*Purpose.* An investigation was conducted to study the requirements of fire clay and bodies used for fire brick in malleable-iron furnace bungs. Tests were made on complete bungs holding forty sample brick in malleable-iron furnace bungs with twenty different fire brick. Laboratory tests were also made in conjunction with them. *Results.* The spalling tests bear the closest relation to the service test; those brick losing less than 10% withstand more than fifteen heats. There is also a relation between the porosities and densities of fire brick, which lie between 15 and 28% and 1.5 and 2.6%, respectively, for the best brick. There is no close relation between the load test and softening points of fire brick and their lifetime in malleable furnace bungs, so these tests are no criterions in judging the serviceability of brick, provided the brick are sufficiently refractory to support the arch at furnace temperature. *Methods for Improving Fire Bricks.* The resistance of a brick to spalling may be governed by: (1) the selection of the proper clays, (2) the size of grain and the proportioning of the non-plastic ingredients, (3) the fineness of grain of the bond clay, (4) the manner of molding, and (5) the temperature of firing.

831. Improvements in the manufacture of zinc refractories during the last twenty-five years.

G. C. STONE. *Jour. Amer. Ceram. Soc.*, **6**, 299–301 (1923).—A short sketch is given of developments in zinc refractories to date.

832. Sagger structure.

F. J. TONE. U. S. 1,448,011, May 22, 1923; *Ceram. Abs.*, **3**, 129 (1924).—In sagger construction, a refractory structural supporting member containing a material other and stronger than sagger material.

833. Tests on some sagger clays and bodies.

ROBERT TWELLS, JR. *Jour. Amer. Ceram. Soc.*, **6**, 949–57 (1923).—*Tests on the Sagger Clays.* Bars were made from three typical sagger clays without the addition of grog. After firing at cone 10½ these bars were tested for linear shrinkage, transverse strength, dry and fired, absorption of moisture, and dye penetration. *Tests on Fireclay-Grog Sagger Bodies.* Two series of bodies were made up into bars. After being fired at cone 10½ the bars were tested for linear shrinkage, transverse strength, dry and fired, and resistance to heat changes. The best body of this type tested was No. 5 which had the composition: No. 8 buff clay, 29.8%; No. 1 fine clay, 18.2%; grog, 6- to 20-mesh, 42.0%; grog, 20-mesh and finer, 10.0%. As a plant test 100 saggers were made from this body. At the end of five fires, three were broken, and fifteen were slightly cracked. *Tests on Some Refractory Bodies Not Commonly Used for Saggers.* Three bodies were made into bars, fired to cone 10½ and tested as before. Two proved much superior to those of the fireclay-grog type. Their compositions are:

No. 12		No. 14	
Georgia kaolin	35%	Kentucky ball clay No. 4	40%
Tennessee ball clay No. 5	10%	Medium sized Carborundum	
Grog, 10–40 mesh	55%	(fire sand)	60%
	100%		100%

These bodies, especially No. 14, are of types ordinarily considered too expensive (their first cost) for general use. Are such bodies actually more expensive, when the cost is figured on the basis of the lives of the saggers? They can be determined only by making plant trials of a large number of saggers, determining the relative "cost per fire."

834. Firebrick arch.

ALFRED H. WILLETT. U. S. 1,463,184, July 31; *Ceram. Abs.*, **2**, 257 (1923).—A tube supported firebrick arch construction comprising a series of pairs of invertible brick supported between two tubes, said brick in each pair being inclined toward and resting against each other and each brick having at the meeting end two oppositely inclined supporting surfaces constructed to permit the brick to be rested against each other either face upward. See *Ceram. Abs.*, **1** [5], 142 (1922); *ibid.*, **1** [7], 185 (1922).

835. Novel experiments in casting huge glass pots prove successful.

ANON. *Ceram. Ind.*, **3** [3], 186 (1924); *Ceram. Abs.*, **3**, 349 (1924).—The U. S. Bureau of Standards recently completed the drying of three experimental pots having outside dimensions of 3 ft. 6 in. in height, 4 ft. 9 in. in diameter and a maximum wall thickness of 5 in. Ten tons of plaster were used in making the mold. The equipment available necessitated mixing and pouring 8 batches of 300 lbs. of plaster each in the casting of a single section of the mold. Since the various sections had to be turned to the proper shape it was necessary for the set of the batches of plaster slip to be retarded progressively by the addition of decreasing amounts of an organic retarder. The mold

was cast and turned to shape on a surfacing wheel which functioned as a turning wheel. 1½ tons of slip were required to cast one pot and no particular difficulty was experienced in this phase of the work. A satisfactory body composition is as follows:

Body	%	Grog	%
Feldspar	4.0	Tenn. ball	50
Tenn. ball 5	16.0	Calcined to cone 10	
Ky. ball 4	9.0	N. C. kaolin	50
N. C. kaolin	12.0	Calcined to cone 10	
Del. kaolin	4.5	Grog Sizing	
Ga. kaolin	4.5	10–20 mesh	20
Flint	4.5	20–40 mesh	30
Grog	50.0	Through 40-mesh	30

836. Coke-oven wall structure.

J. VAN ACKEREN. U. S. 1,486,401, Mar. 11, 1924; *Ceram. Abs.*, **3**, 130 (1924).—In a coke-oven structure, in combination: a heating wall comprising spaced silica liner-brick sections connected together at intervals by silica tie-brick sections to form flame flues within said heating wall, the ends of said liner-brick sections being formed with jogged edges; a clay jamb-brick section positioned at the end of the heating wall and provided with companion jogged edges for engagement with the aforesaid jogged edges of the liner-brick section; and a substantially co-extending vertical joint interposed between said jamb-brick section and the adjacent tie brick section of the heating wall, said joint composed of silica sand, to accommodate heterogeneous expansion or contraction of the jamb-brick section and the heating wall; substantially as specified.

837. What demands are made today upon the refractory materials in the cement industry?

K. ENDELL. *Zement*, **13**, 230–33 (1924); *Ceram. Abs.*, **7**, 318 (1924).—Combining the usual testing of refractories with their life in practice., E. finds the kiln linings of clinker and cement to be the most economical. The apparatus used to determine the deformation of materials under load while heating is described. The action of the fusing clinker upon kiln linings is discussed.

838. Refractory lining for metallurgical purposes.

E. W. HALE. U. S. 1,492,685, May 6, 1924; *Ceram. Abs.*, **3**, 221 (1924).—As an article of manufacture, a container for molten metals and other materials, the portions of the lining of which container most liable to be exposed to the destructive action of the molten materials and gases are faced with bricks made of an alloy containing chromium.

839. Investigations leading to the discovery of the cause of excessive sagger breakage.

W. STEGER. *Trans. Ger. Ceram. Soc.*, **5**, 3 (1924); *Ceram. Abs.*, **4**, 136 (1925).—Three main causes are (1) use of unsuitable raw materials and unfavorable batch composition; (2) imperfect preparation of the batch; (3) improper firing. This article only covers investigation under (1) and by determining and charting the thermal expansion in 4 temperature zones between 20° and 750°C of clays varying in free silica content between 3 and 73% the critical periods of quartz and cristobalite inversion are clearly shown. The rapid expansion of the clays high in free SiO_2 naturally leads to lowered resistance in temperature changes and it is therefore important that in the initial firing all the free SiO_2 is taken into solution. The tests brought out that all clays containing free SiO_2 have certain critical temperature ranges in which they are more susceptible to temperature changes on account of the changes of the quartz to other forms. The extent of the volume changes involved is dependent on the grain size and crystallic nature of SiO_2 bearing material, the finer the grain the greater the change in volume.

Materials suggested to take the place of quartz are materials with high alumina content, Carborundum, and natural sillimanite.

840. Chamotte retort with internal protective layer and curved wall.

STETTINER CHAMOTTE FABRIK A. G. Ger., 368,454. *Chem. Tech. Uebersicht*, 192; *Chem. Zeit.*, **48**, 130–32 (1924); *Ceram. Abs.*, **4**, 107 (1925).

841. Comparative service tests of grossalmerode and domestic clay pots.

W. S. WILLIAMS. *Bull. Amer. Ceram. Soc.*, **3**, 413–17 (1924).—Comparison of results obtained by foreign and domestic clays.

842. Effect of variations in cupola practice on the life of refractory blocks.

J. T. MACKENZIE. *Jour. Amer. Ceram. Soc.*, **8**, 720–34 (1925).—M. discusses chemical, mechanical, and physical influences on cupola linings and their combined effects. A brief description of common practice in lining, preparation, and charging of the cupola is followed by a discussion of the effect of the daubing practice, the character of fuel, metal, flux, and blast. The principal point of the paper is the injurious effect of oxidation resulting from thin or rusty scrap and from too high velocity of the blast.

843. Refractory requirements in the gray iron foundry.

R. MOLDENKE. *Jour. Amer. Ceram. Soc.*, **8**, 712–19 (1925).—The author calls attention to the lack of information on foundry refractories on the part of both foundrymen and makers of refractory materials. The applications of these materials in foundry practice are enumerated, and the requirements detailed sufficiently to enable the manufacturer to select the proper grades of brick and clay for cupola and air furnace, as well as for the lining up of ladles.

844. Centrifugal method of making small pots of electrically fused refractory materials.

F. S. TRITTON. *Proc. Roy. Soc.*, **107A**, 287–90 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 208 (1925); *Ceram. Abs.*, **4**, 166 (1925).—Powdered MgO, Al_2O_3, or ZrO_2, is rotated in cup-shaped mold and is meantime fused by an arc between two carbon rods dipping into the central part of the mold. The time required to produce a pot is 15 minutes. Tendency to form carbides, in the case of Al_2O_3 or ZrO_2, is eliminated by directing a stream of O into the mold.

REFRACTORY CEMENTS, MORTARS, AND BONDING MATERIALS

845. Refractory mortars and slag linings.

J. W. RICHARDS. *Trans. Faraday Soc.*, **12**, 148 (1917); *Trans. Ceram. Soc.* (Eng.), **16**, 88 (1917).—The best clay mortar for fireclay brick is one as high as possible in Al_2O_3. Low alumina has a high fluxing action on the fire bricks. The best mortar for SiO_2 brick is one as low in alumina as possible. A high alumina mortar has a powerful fluxing action on silica brick. The only rational test is to test the brick and mortar in intimate contact so as to determine the melting point of the product.

846. Fire-resisting composition.

R. F. BOLT. U. S. 1,318,960, October 14, 1919; *Jour. Amer. Ceram. Soc.*, **2**, 1023 (1919).—This composition is designed especially for use in the lower portions of heating furnaces employed in steel mills. It consists of clay, common clay, or fire clay, 25%, and roll scale 75%.

847. Refractory cement.

H. B. BOOTH. U. S. 1,321,085, November 11, 1919; *Jour. Amer. Ceram. Soc.*, **3**, 82 (1920).—This cement is designed particularly for protectively coating electrodes.

It consists of feldspar 15–40%, artificially crushed quartz 40–20%, silica sand 15%, and 30–15% of a binder consisting of sodium silicate 92 parts, sodium sulphate 8 parts, and water. The feldspar content is varied, depending upon the heat. For an electrode heating to 3000°F, 15% feldspar, 40% crushed quartz is used, while for an electrode heating to 1500°F, 40% feldspar, 20% crushed quartz is preferred.

848. Cement refractory.

ANON. *Tonind. Ztg.*, **44,** 32(1920); *Jour. Amer. Ceram. Soc.*, **3,** 416(1920).—The cementing action of refractory cement is not similar to that of Portland cement, but its cementing action is due to the partial fusion of the mortar which in combining with the brick hold the brick together.

849. Use of fire clay in laying fireclay brick.

R. M. HOWE. *Clay Worker*, 136–37(1920); *Jour. Amer. Ceram. Soc.*, **3,** 330(1920).—The effect of certain materials such as cement and sodium silicate when added to a fireclay mortar is given. The effects of these ingredients on the fusibility of a cone 30 bond clay were studied and the results are given in a table. The addition of first quality brick bats gave the most refractory materials. A thick layer of mortar is recommended.

850. Test of fireclay mortars.

R. M. HOWE. *Gas Age*, **45,** 174–76(1920); *Iron Trade Rev.*, **66,** 417–19(1920); *C. A.*, **14,** 1420(1920).—Experiments were made to determine the effect on fusion temperatures of mixing with a very plastic fire clay different amounts of water-glass, Portland cement, Carborundum, asbestos, and lime. The results are tabulated and shown graphically.

851. Mortar refractory.

R. KLINGER. *Tonind. Ztg.*, **44,** 17(1920); *Jour. Amer. Ceram. Soc.*, **3,** 334(1920).—A good refractory mortar should increase in strength during service as lime mortars do when used with building brick. It should not melt at the temperature of the furnace and should show a small fire shrinkage. The chemical analysis should be adapted to the type of brick with which it is used.

852. Mortar refractory.

R. KLINGER. *Tonind. Ztg.*, **44,** 132(1920); *Jour. Amer. Ceram. Soc.*, **3,** 334(1920).—Cracking of the brick work in furnaces seldom occurs in a new furnace where the mortar is still in an unfused state, while later on when this mortar becomes fused there is a decided tendency for the brick to crack.

853. Refractory cements.

W. S. QUIGLEY. *Trans. Amer. Foundryman's Assn.*, **28,** 479–80(1920); *Jour. Inst. Metals*, **26,** 655; *Ceram. Abs.*, **2,** 20(1923).—Q. divides bonding materials into four classes, *viz.*: (1) fire clay; (2) coarse grades of mixed materials (so-called cements); (3) cements depending upon a fibrous structure for holding component parts together; (4) cements capable of universal application. (1) and (2) have no binding strength of themselves unless subjected to a vitrifying temperature, and then only a surface bond is obtained, owing to the inability of heat to penetrate the entire thickness of the wall. The result is a vitrified shell with a weak structural backing, which frequently bulges or collapses. The third type loses its binding properties as the temperature increases. The fourth type, to be of universal application, should air-set, and its binding properties should be independent of heat. It should be passed through a fine sieve so as to obviate the formation of voids between bricks. It should be capable of being used as a binder with crushed fire brick, old crucibles, fine sand, fire clay, ganister, for making rammed-in

linings, and for doing repair work (unadmixed if necessary) hot or cold. It should have as nearly as possible the same coefficient of expansion as that of the materials with which it is used as a bond. A cement with a coefficient intermediate between those of fireclay brick and silica brick (0.075 in. and 0.175 in., respectively, per ft. at 1200°) could be advantageously used with either.

854. Method of constructing one-piece firebrick arch.

WILLIAM A. A. SCHAFFER. U. S. 1,341,077, May 25, 1920; *Jour. Amer. Ceram. Soc.*, **3,** 691 (1920).—The method consists in arranging a bar or pipe through a boiler setting, anchoring the opposite ends of the bar or pipe in the walls of the boiler setting, then anchoring one end of a metallic sheet or plate in one of the walls of the boiler setting, supporting the opposite end of the sheet or plate upon the bar or pipe and then installing a mass of plastic firebrick material upon said metallic sheet in the form of the desired arch.

855. Mortar refractory.

W. B. SCHEIDT. *Tonind. Ztg.*, **44,** 86–87 (1920); *Jour. Amer. Ceram. Soc.*, **3,** 334 (1920).—Discussion of a paper in *ibid.*, **44,** 17 (1920). Fusion to a certain degree is desirable in refractory mortar as this binds the brick together, whereas if the mortar were not fused the brick work would be more or less loose. In furnaces where the mortar is too refractory, large cracks occur, due to the expansion and contracting of the brick work, due to heating and cooling.

856. Cements for joining refractory brick.

ANON. *Rev. Mat. Constr. Trav. Pub.*, **136,** 11B (1921); *Jour. Amer. Ceram. Soc.*, **4,** 686 (1921).—The effects of the addition of various materials on the fusibility of a clay are given in an accompanying table. The fusion temperatures are expressed in cones. Carborundum and refractory brick maintained the refractoriness while the rest of the materials lowered it considerably.

857. Refractory material.

EDWARD D. FROHMAN. U. S. 1,375,016, March 22, 1921; *Jour. Amer. Ceram. Soc.*, **4,** 775 (1925).—A refractory material consisting of a mixture of finely divided dry fire clay, siliceous material, and a vegetable compound capable when mingled with water of forming a binder.

858. Refractory compositions.

R. SCHAEFER ET CIE AND H. SCHAEFER. Brit. 196,021, Dec. 13, 1921; *Ceram. Abs.*, **3,** 16 (1924).—Refractory compositions for making metallurgical or other furnaces by molding are prepared by grinding waste siliceous bricks that have been used in furnaces with an organic binder. Suitable proportions are 100 parts of powder to 5 parts of binder. Binders specified are non-hygroscopic organic agglutinants soluble in H_2O, such as dextrin, amylaceous materials, albuminoids, glucosides, glucoses, gelatins, and sulphitted liquors or residues; and carbonaceous materials such as resin or asphalt. The composition is mixed with H_2O, naphtha, or other solvent of the binder, molded and dried, and is baked *in situ* by lighting the furnace.

859. Zirconia cements.

M. SHEPPARD. *Jour. Amer. Ceram. Soc.*, **4,** 662–68 (1921); *Trans. Ceram. Soc.* (Eng.), **21,** 59A (1922).—Raw Zr when used as a cement cracks on account of its high shrinkage. 50% calcined Zr eliminates this cracking. Compositions. Firing. Load tests—no failure. Life of a bung in a malleable iron furnace was increased 25% by the use of Zr for a wash.

860. Refractory cements and protective coatings.

C. E. BALES. *Clay Worker*, **78**, 140 (1922); *Ceram. Abs.*, **1**, 276 (1922).—B. discusses the effect of substances most commonly added to fire clay and their effect. Common salt, sand, cement, water-glass, lime, and asbestos decrease the refractoriness of fire clays while fireclay grog increases the refractoriness. Carborundum dust mixed to a pasty consistency with water, makes a very good protective coating but it does not add a great deal to the life of the refractory.

861. Acid proof refractory composition.

H. P. BASSETT. U. S. 1,390,327, Sept. 13, 1922; *Ceram. Abs.*, **1**, 11 (1922).—The hereindescribed acid proof refractory composition comprising silica, a metal comprised within the iron and aluminum groups, an alkali metal compound and a silicate binder.

862. Refractory composition.

D. E. COLLINS. U. S. 1,411,842, April 4, 1922; *Ceram. Abs.*, **1**, 210 (1922).—A refractory bonding and glazing composition comprising fire clay, a hydraulic cement and a metallic sulphide.

863. A new cupola lining.

K. GROCHOLL. *Die Giesserei; Iron Age*, **110**, 1279 (1922); *Ceram. Abs.*, **2**, 100 (1923).—In Germany a loose refractory mixture is being used for ramming up the cupola lining, instead of fire brick and blocks. The cost is only $\frac{1}{30}$ that of fire brick. Patching is done after every heat, with unskilled labor, and a new lining is not required within 2 years.

864. Refractory materials for lining furnaces.

J. HODSON. Brit. 211,944, Nov. 28, 1922; *Ceram. Abs.*, **3**, 290 (1924).—Bricks, furnace linings, retorts or similar products are formed from rocks containing $MgCO_3$ and $CaCO_3$ together with either (*a*) talc or other form of Mg silicate, (*b*) igneous rocks with or without basic Fe cores, or either *a* or *b* plus silica sand; *e.g.*, SiO_2 15, serpentine 5, raw dolomite 10 and burnt dolomite 70%. The material may be molded with or without a glutinous binder, then fired, or may be fired to a plastic state and then molded. Raw magnesite 92.5, SiO_2 sand 5, and clay 2.5% also may be used.

865. Refractory material.

R. W. HULL. U. S. 1,418,648, June 6; *Ceram. Abs.*, **1**, 280 (1922).—A refractory material adapted for lining furnaces if formed of the residue remaining from the concentration of Cr ore containing a mixture of SiO_2 serpentine and olivine, united by a binder such as pitch, tar or Al_2O_3.

866. Rendering furnace walls impervious to gases.

C. M. SHIPMAN. U. S. 1,387,739, Aug. 16; *Ceram. Abs.*, **1**, 183 (1922).—Furnace walls are rendered impervious to the passage of hot combustion gases by treating the walls with a slurry formed of clay, SiO_2, and soluble silicate and then exposing the treated walls to hot combustion gases.

867. Refractory article and the method of making the same.

FRANK B. DANEHOWER. U. S. 1,450,140, Mar. 27, 1923; *Ceram. Abs.*, **2**, 183 (1923).—A refractory article of manufacture being a baked product and comprising a comminuted refractory body and the residue of decomposition of synthetic phenol resin which acts as a bond for the comminuted refractory body.

868. Manufacture of self-hardening refractory articles.

WILLIAM A. FRANCE. U. S. 1,451,540, Apr. 10, 1923; *Ceram. Abs.*, **2**, 182 (1923).—The method of manufacturing refractory articles, such as furnace-lining bricks, which

consists in mixing magnesite with other elements including magnesium chloride in a molten condition, forming the same, and finishing the resultant by subjecting it to the drying action of air and without firing.

869. Jointing materials for silica refractories.

D. JONES AND W. EMERY. *Gas Jour.*, **163,** 157–59 (1923); *Gas World*, **78,** 646; *Ceram. Abs.*, **3,** 116 (1924); *C. A.*, **17,** 3409 (1923).—Most satisfactory results for jointing cements are obtained when it is similar to the brick used. Mixtures of fire clay, ganister, and crushed silica brick high in ganister gave good results. A small per cent of highly plastic refractory clay is better than a large per cent of less plastic fire clay for bonding. No advantage is obtained by use of plaster, lime or sodium silicate to a high temperature cement.

870. Requirements of a refractory mortar.

R. F. LINDSAY. *Chem. Met. Eng.*, **28,** 1080 (1923); *Ceram. Abs.*, **2,** 256 (1923).—A refractory mortar must have a melting point close to that of the brick with which it is used. The expansion and contraction of the mortar and also its chemical properties should be similar to those of the brick.

871. Silica cement

E. N. MCGEE. *Jour. Amer. Ceram. Soc.*, **6,** 896–903 (1923).—Composition, requirements and specifications for first quality silica cement are discussed. Adequate control tests for determining its suitability are described, together with such investigations as have been made for the purpose of obtaining a satisfactory cement. The latter part of the paper deals with the bonding qualities. An investigation showed that the use of molasses greatly improved the bond without affecting the refractoriness.

872. Bauxite cements (Ciments fondus).

GABRIEL PATROUILLEAU. *Le Ciment*, **28,** 259–60 (1923); *Ceram. Abs.*, **3,** 75 (1924).—It is suggested that the bauxite cement of average percentage composition SiO_2 12, Al_2O_3 44, CaO 44, with a corresponding molecular composition 1 SiO_2, 2 Al_2O_3, 4 CaO is a very basic oxysilico-aluminate of lime, which may be written SiO_2, Al_2O_3, $CaO+mAl_2O_3$ nCaO.

873. Refractory cement.

W. F. ROCHOW. Can. 229,684, Mar. 20, 1923; *Ceram. Abs.*, **3,** 131 (1924).—A composition for refractory cement contains powdered SiO_2 rock, calcined SiO_2 and dry powdered Na_2SiO_3.

874. On refractory cement.

TEI TAKAMATSU AND MASATAKE KUWAYAMA. *Jour. Jap. Ceram. Soc.*, **368,** 167–75 (1923); *Ceram. Abs.*, **2,** 254 (1923).—The authors have worked for the production of substitutes for "hytempite" which is imported from America. Hytempite has alkaline reaction, its strength corresponding to 0.0276 g. NaOH per g. of sample. Analysis of dried sample is: Total silica 68.66, soluble silica 4.33, alumina 16.26, ferric oxide 2.60, lime 1.25, magnesia 0.92, soda 3.73, and loss on ignition 6.53%. It melts at about cone 15, while its insoluble portion has a refractoriness of cone 27. The effect of adding different amounts of water-glass to the insoluble portion of hytempite, 7 kinds of domestic clays and a diatomaceous earth on their refractoriness are shown; the results indicate a close similarity between Mizuno clay and the insoluble portion of hytempite. The experiments of manufacturing refractory cement with Mizuno clay, grog, and water-glass are reported. Analyses of these materials are:

	SiO_2	Al_2O_3	Fe_2O_3	CaO	Mg	Na	Ignition loss
Mizuno clay	69.12	16.68	0.55	1.80	0.99	...	8.20
Grog	73.20	21.84	.90	1.24	.83	...	...
Water-glass	36.56	...	...	...	...	18.81	44.63

Two small slabs cut from fire brick were cemented with each mixt. The blocks were then heated at 1350°C (for 8 hrs.), 1580° (100 hrs.), 1510° (104 hrs.), 1470° (110 hrs.), 1490° (113 hrs.) and 1345° (10 hrs.). Then they were tested as cements for cracked glass pots. The following mixtures together with several others are at least as good as hytempite:

No.	Mizuno clay	Water-glass	Grog	Water
20	30	15	55	9
42	30	25	45	5
43	25	25	50	5

875. Furnace settings and refractory cements.

F. J. WALSEM. *Ind. Eng. Chem.*, **15,** 893–94 (1923); *C. A.*, **17,** 3409 (1923).—A general discussion of failures due to plastic deformation, spalling, cracking, or bulging, clinkering, melting, and slagging. A dry high temperature cement is preferable to a plastic cement. Excess of water should be avoided.

876. Reducing the cost of relining boiler furnaces.

ANON. *Power*, **59,** 1028 (1924); *Ceram. Abs.*, **4,** 288 (1924).—A method is described of patching old furnace linings by means of a refractory cement of suitable properties so that it may be shot into cracks and crevices by means of a cement gun. The cement is a mixture of fine grog and silicate of soda. The article is illustrated with furnace wall photographs showing the character of furnace walls before and after re-lining.

877. Refractory mortar and cement composition.

C. G. CARLSTRUM. U. S. 1,511,503, Oct. 14, 1924; *Ceram. Abs.*, **4,** 17 (1925).—The hereindescribed composition of refractory materials, for making of refractory mortars, cements or plasters, consisting of fire clay not more than 20% of the total mass, salt not more than 2% of the total mass, coal ash not less than 68% of the total mass and ganister rock not more than 10% of the total mass, substantially as described.

878. Proper clay for furnace walls.

M. S. GEREND. *Power*, **60,** 761 (1924); *C. A.*, **19,** 711 (1925).—Fire clay in which the brick of boiler furnaces is set, has little mechanical strength. Binders are desirable if they do not act as a flux. A graph illustrates the reduction in fusion point of fire clay due to the addition in various proportions of lime, Portland cement, asbestos, water-glass, and Carborundum.

879. Bonding high-temperature refractories.

R. C. GOSREAU. *Chem. Met. Eng.*, **31,** 696–98 (1924); *Ceram. Abs.*, **4,** 77 (1925); *Sci. Abs.*, **28B,** 123 (1925).—An article dealing with the selection of bonding materials for use in patching, fettling and making monolithic linings. The use of grain and powder refractories and their bonding materials is dealt with. Binders used are acids, alkalis, salts, oxides, silicates, and organic materials. Magnesia and zircon are the principal refractories. Tabular results are given.

880. Ground fire brick for furnace repair.

JOSEPH HARRINGTON. *Power*, **59,** 976 (1924); *Ceram. Abs.*, **3,** 288 (1924).—Furnace walls are laid up with thick joints of a refractory cement made of firebrick grog mixed

with a refractory cement or else the walls are of monolithic construction using this cement. The grog in the cement is ground firebrick bats of the same quality as the brick of the walls. A saving is claimed in laying up new walls with thick joints of this cement. The monolithic walls apparently show long life.

881. New use for refuse refractory material.

S. F. WALTON. *Iron Age*, **113**, 786–88 (1924); *Ceram. Abs.*, **3** [10], 294 (1924).—Old fireclay brick bats are ground up with a bond to form a highly refractory mortar. Economies claimed are: the mortar is inexpensive, the mortar and plaster conserve firebrick walls and arches, the new plaster can be applied instead of re-laying brick, and fuel is conserved by the prevention of air infiltration through cracks.

882. The laboratory testing of plastic refractories.

R. F. GELLER AND W. L. PENDERGAST. *Jour. Amer. Ceram. Soc.*, **8**, 441–51 (1925); *C. A.*, **19**, 3153 (1925).—Twelve brands from 9 manufacturers were tested. The H_2O content was 9.3–15.7, av. 12%. Drying shrinkage was quite uniform, about 1.5%. The dry modulus of rupture was 33–57, av. 48.6 lb./in. Screen test showed 60% grog, variations in sizing showing no marked effects. Silica was 43.8–65.6; alumina, 30.9–50.8; Fe_2O_3, 0.6–1.9; TiO_2, 0.2–2.3; and alkalis (by difference) 0.2–2.4%. Softening point was cones 30–34. Resistance to spalling was uniformly high.

883. Composite refractory body.

J. W. MARDEN AND H. K. RICHARDSON. U. S. 1,554,225, Sept. 22; *Ceram. Abs.*, **4**, 347 (1925).—As an article of manufacture a composite body comprising a ceramic refractory material to at least part of the surface of which a substantial layer of practically pure thorium oxide is affixed. The method of producing a composite refractory body which comprises preparing a slip of finely divided thorium oxide, a salt adapted to function similarly to a colloid, a medium adapted to precipitate any colloid and to produce a suitable consistency for casting, subsequently applying the thus formed slip to ceramic material and drying.

884. Refractory furnace lining.

D. H. MELOCHE. U. S. 1,534,237, April 21, 1925; *Ceram. Abs.*, **4**, 168 (1925).—The method of protecting and repairing the refractory lining of a furnace which consists in first heating the refractory surface of the furnace to between 300 and 500°F, then painting the heated surface of the furnace with a wash containing not over 10% of soluble silicate in solution and a considerable quantity of powdered fire clay in suspension; heating the surface of the furnace, then applying another thin coat of fire clay with the soluble silicate binder; again heating the surface of the furnace, and repeating the operation until the desired thickness of fire clay is applied to the surface of the furnace.

885. Further notes on the refractory properties of zirconia.

H. C. MEYER. *Met. Chem. Eng.*, **13**, 263 (1925); *Trans. Ceram. Soc.* (Eng.), **17**, 111A (1917–18).—Heat tests: Zr mixed with Bens Creek clay, Warrior Ridge clay and lime. 5% of Warrior Ridge clay gave best results with pure Zr next. Fire shrinkage: Differently treated Zr gave varying results. Binders: Seven different binders were tried with fair results. Fireclay bond: 5% of Warrior Ridge clay with the Zr formed a brick superior to magnesite when placed in the wall of an electric furnace and fired to 1800°C.

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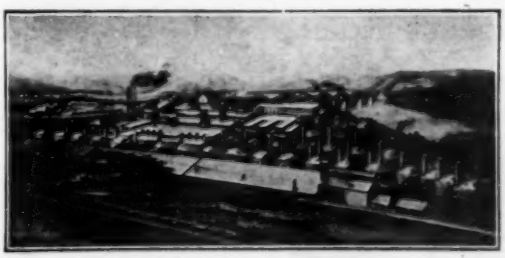

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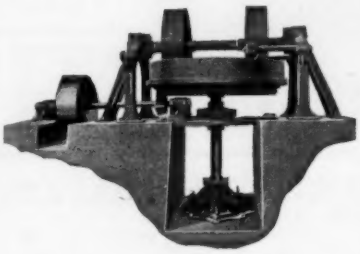

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Magnesite Refractories Bibliography	41	No charge	3c
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